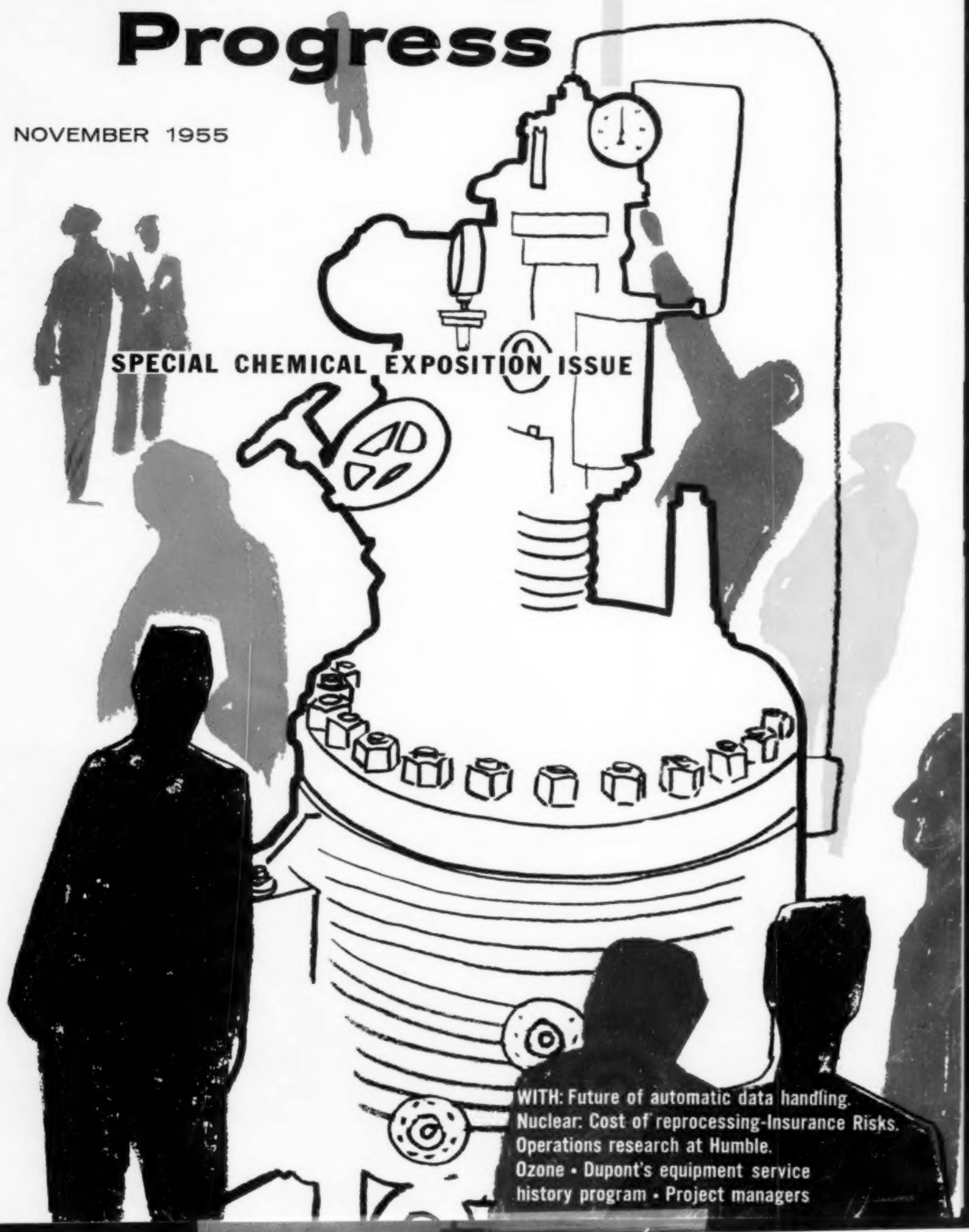
Chemical Engineering Progress

The new **DATA** on equipment and materials

NOVEMBER 1955



SPECIAL CHEMICAL EXPOSITION ISSUE

WITH: Future of automatic data handling.
Nuclear: Cost of reprocessing-Insurance Risks.
Operations research at Humble.
Ozone • Dupont's equipment service history program • Project managers

Chemical Engineering Progress

NOVEMBER, 1955 • Volume 51, No. 11

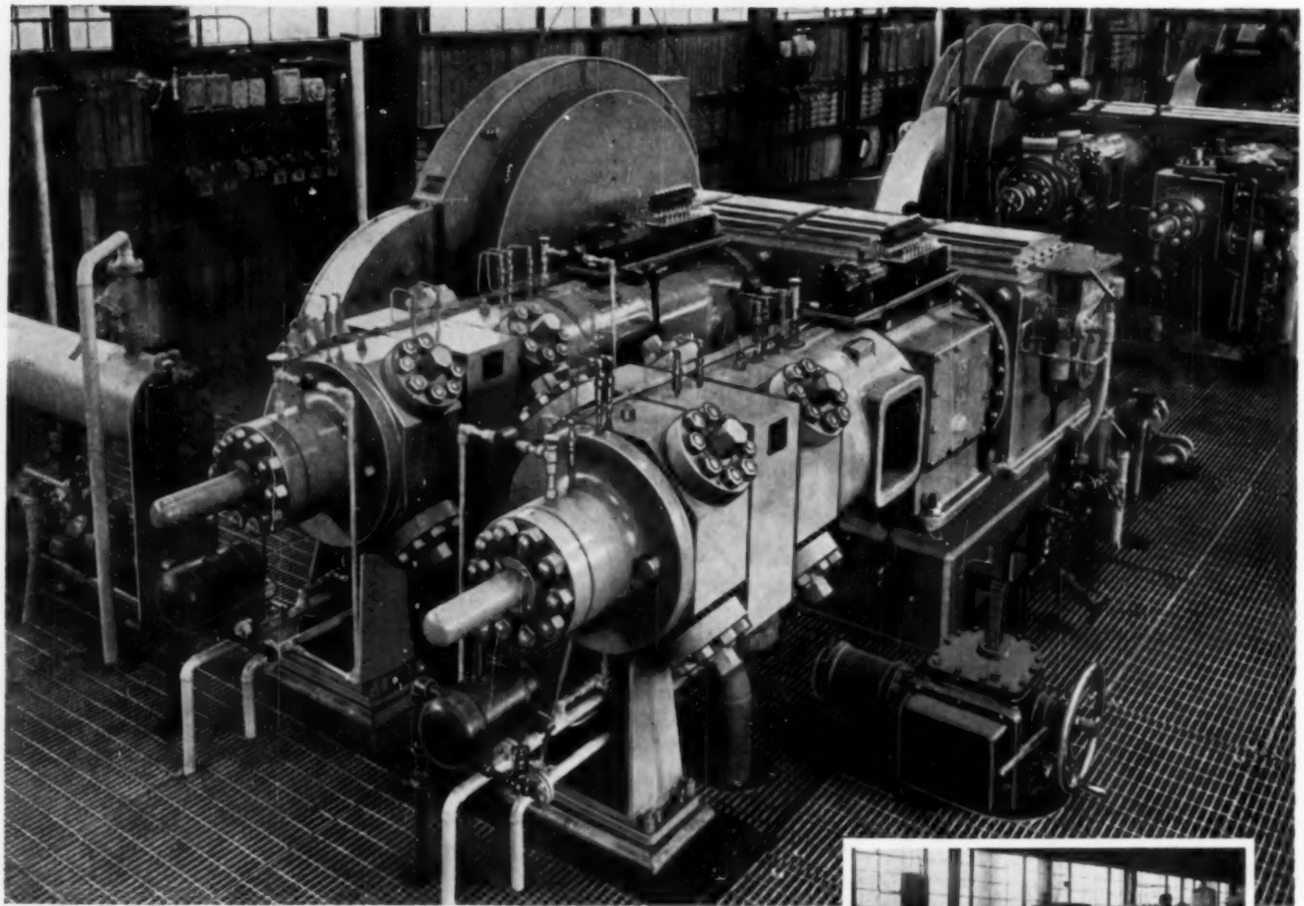
What's In This Issue

(Continued on page 7)

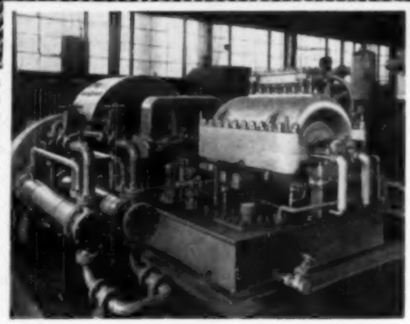
Cover design by Milton Wynne Associates

Published monthly by American Institute of Chemical Engineers at 15 North Seventh Street, Philadelphia 6, Pennsylvania, Editorial and Advertising Offices, 25 West 45th Street, New York 36, N. Y. Communications should be sent to the Editor. Statements and opinions in *Chemical Engineering Progress* are those of the contributors, and the American Institute of Chemical Engineers assumes no responsibility for them. Subscriptions: U. S. and possessions, one year $6.00; two years $10.00 (Applies to U. S. and possessions only.) Canada, $6.50; Pan American Union, $7.50; Other Foreign, $8.00. Single Copies of *Chemical Engineering Progress* older than one year cost $1.00 a copy; others are 75 cents. Entered as second class matter December 9, 1946, at the Post Office at Philadelphia, Pennsylvania, under Act of August 24, 1912.

Member of Audit Bureau of Circulations. *Chemical Engineering Progress* is indexed regularly by Engineering Index, Inc.



Synthesis gas that did not combine to form ammonia during its stay in the converter is recirculated by this HHE compressor. Each of the two cylinders increases the pressure of the hydrogen-nitrogen mixture 400 psi. Design maximum working pressure is 3815 psia. This 212 cfm unit is driven by a 500 hp motor.



Air is compressed in this 1750-hp centrifugal compressor for liquifaction and separation of nitrogen. The nitrogen is combined with the hydrogen to form the synthesis gas and for a nitrogen wash in gas purification.

PRESSURE is an all important factor in the manufacture of synthetic ammonia. Many different pressures, high and low, must be held to the exact process requirements. Also, the nature of the gases being compressed varies due to differences in chemical properties.

At the Atlantic Refining Company's new ammonia synthesis plant, all pressure and capacity requirements are easily met by the I-R centrifugal compressor and the seven versatile HHE reciprocating compressors, a total of 6110 horsepower. Air and seven other gases or mixtures of gases are handled by these heavy-duty units.

This is an interesting example of the *complete flexibility* of I-R process compressor design. Either centrifugal or reciprocating compressors can be supplied, whichever type best meets existing economic conditions. Or, as in this plant, both types of compressors may be used in conjunction with each other.

Whatever the process, you can meet your *exact requirements* with process-engineered Ingersoll-Rand compressors. It will pay you to call in your I-R representative on your next job.

ROCK DRILLS • AIR AND ELECTRICAL TOOLS • VACUUM EQUIPMENT

CEP what's in this issue...

(Continued from page 3)

LETTERS TO THE EDITOR

Local Sections—Do Likewise!

It was with some surprise and a great deal of pleasure that I read of our Western New York Section round table meetings in the September issue of Chemical Engineering Progress. That was a very nice write-up and someone is to be congratulated on his editorial efforts. A nice piece of advertising for our section and a wonderful piece of public relations with the rest of the Institute . . . Articles like this in Chemical Engineering Progress show what a fine job you are doing with the local section.

James W. Casten
Buffalo, New York

The above letter was written by James W. Casten to William Greenwald, electrochemicals department of DuPont and chairman of Western New York Section. This letter, copy of which was sent to this office, speaks for itself.

Editor

Oh Men, Oh Women—That's the Problem

The article "Chemical Engineering and Science Engineering," by Dr. R. R. White, like most of those published in C.E.P. the past few years on the same general subject, discloses one serious flaw in our educational procedures. An engineering education, particularly one in chemical engineering, provides an excellent training for almost any field of endeavor. As Dr. White points out, the result of this training is to provide some kind of an answer to any problem. However, an answer is not enough. To accomplish anything with the answer, one must deal with *people,* and our educational program provides little if any training along these lines.

The ability to handle people—bosses, fellow-workers, and employees—to work cooperatively with them, to lead and inspire them, to sell them, to manage them—is far more important to an engineer both in

(*Continued on page* 10)

LETTER TO THE EDITOR

(*Continued from page* 8)

terms of his technical accomplishments and his financial reward—than any purely technical ability he has. This is a hard lesson for an engineer to learn, and the most important one. Few people today work alone, yet the engineers are not given from the start the basic tools for solving problems of *people* along with the problems of *things*.

Someplace our engineering courses must provide the basic training in this field as a continuing requisite throughout formal schooling.

WILLIAM B. KATZ
Evanston, Illinois

A Round Table That Rang a Bell

The Round Table on Equipment and Maintenance History reported in the September issue of CEP, starting with page 385, was one of the most interesting and potentially useful magazine features it has ever been my pleasure to read and study. I would vote for more of this kind of thing in the future.

JUSTUS O'REILLY
El Dorado, Kansas

Reader Wants an Answer. . . .

We have read the very interesting report of the maintenance round table held by Chemical Engineering Progress. On page 390, the participants discuss costs and indicate an industry measuring stick of about 8% of invested capital. A figure as high as 8% baffles us somewhat and we are wondering what maintenance cost definition was used: therein, perhaps, is our misunderstanding. Our conception is that in a group of companies such as represented at this discussion, a very proper figure would be in a 4 to 5% league.

Any comments would certainly be appreciated.

L. D. DOUGAN
Sarnia, Canada

. . . He Gets It.

The editor of CHEMICAL ENGINEERING PROGRESS has asked me to reply directly to your question about the magnitude of maintenance as a % of invested capital. My offhand remark at the round table conference that maintenance is often taken as 8% of investment for new installations was like most generalizations—subject to various limitations and qualifications, depending upon such factors as the distinction between capital and expense in different companies, whether or not overhead is charged on maintenance labor, how much corrosive material is handled, etc.

It is in accordance with my own experience, however, that in many chemical

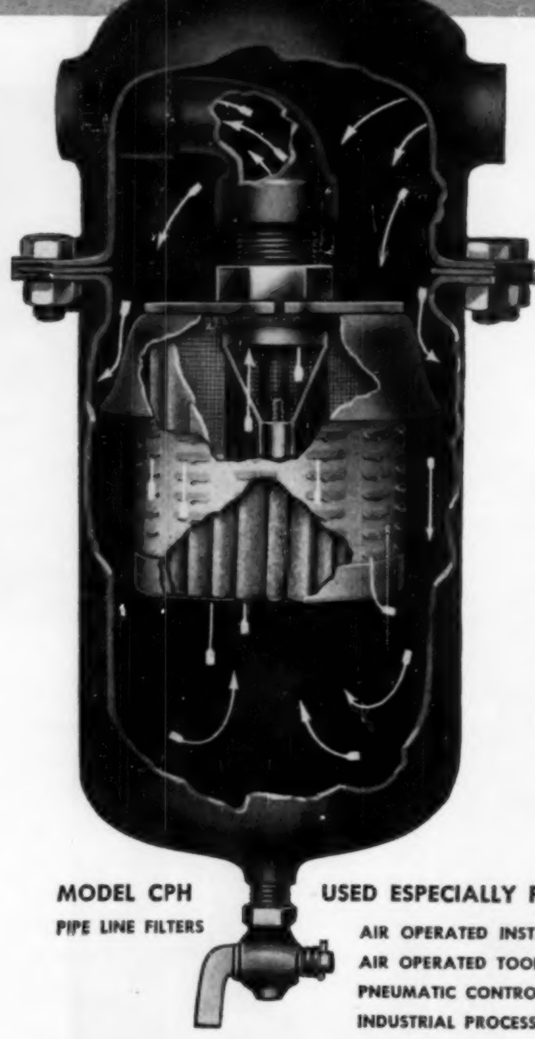
(*Continued on page* 18)

SPECIFY

STAYNEW PIPE LINE FILTERS

FOR CLEAN, DRY AIR

GUARD AGAINST | **WATER OIL PIPE SCALE**



Staynew's "double-action principle" assures sustained, trouble-free operation at high load factors.

1. Deflector cup directs flow of air or gas, together with water, oil and dirt, to the walls of the housing and then downward at high velocity into the base, where water, oil and heavier particles of rust, scale and dirt are deposited.

2. The air or gas having been mechanically cleaned, rises at low velocity through the Radial Fin Filtering Insert which removes the lighter air-borne material.

Efficient design eliminates need for frequent cleaning. Interior parts of filters are easily accessible for inspection and cleaning.

Inexpensive, quickly installed and easily maintained, these filters keep air operated or controlled equipment free from pipe scale, dust, dirt, and condensate. Wherever you require air and other gases *clean* and *dry*, specify Staynew Pipe Line Filters.

MODEL CPH
PIPE LINE FILTERS

USED ESPECIALLY FOR:

- AIR OPERATED INSTRUMENTS
- AIR OPERATED TOOLS
- PNEUMATIC CONTROLS
- INDUSTRIAL PROCESSES

WRITE for Bulletin 200 containing photos, charts and engineering data. Our Engineering Department welcomes the opportunity to help solve your air filtration problems.

DOLLINGER PROTECTOMOTOR STAYNEW FILTERS

DOLLINGER
CORPORATION
79 CENTRE PK., ROCHESTER 3, N. Y.

ALL TYPES OF FILTERS FOR EVERY INDUSTRIAL NEED

LETTERS TO THE EDITOR

(*Continued from page* 10)

plants where corrosion is a factor, the cost of labor, repair material, and overhead often equals or exceeds the 8% figure. The term maintenance generally covers not only true repairs but also dismantling and alterations as well as miscellaneous services rendered through the Mechanical Department of the plant, such as yard cleaning, snow removal, and other jobs that are not chargeable to capital. Limited strictly to repairs, the maintenance cost would ordinarily be 6 to 7% of investment for the cases where 8% is cited.

You may be interested in an article published in *The Controller*, May, 1951, in which the author, Ray H. Bartlett, discusses "What Does Maintenance Cost and What Can You Do About It?". From a survey of 400 firms, not limited to any one industry, the author states that the majority of industries and companies spend each year over 12% of the net property valuation on maintenance! For any individual plant, I think that there are other and better ways of comparing maintenance performance but the ratio of this expense to the invested capital is still an arresting figure.

D. E. Pierce

Cleveland, Ohio

NOTED AND QUOTED

The Tiny Atom and the Enormous Ocean!

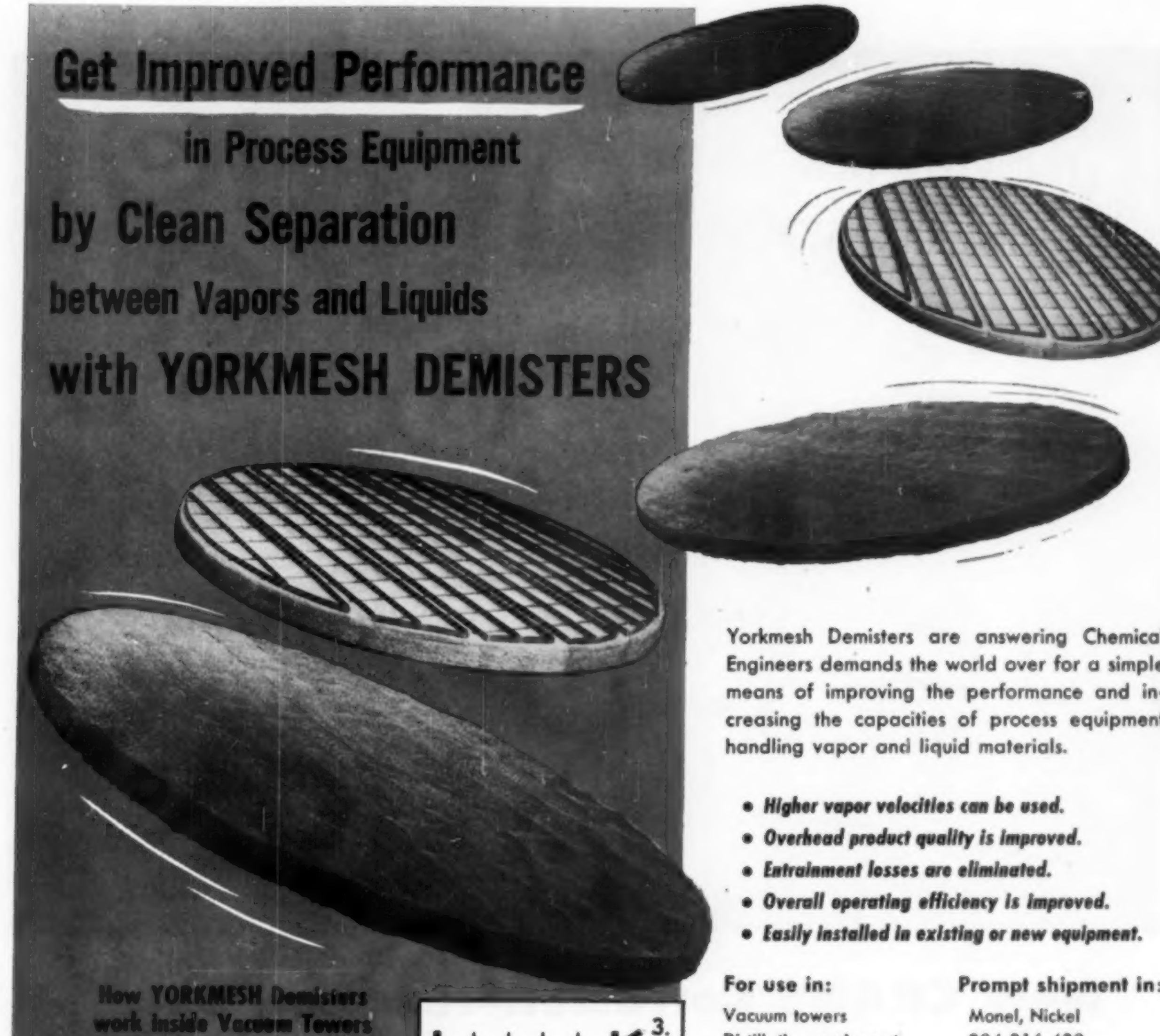
The quantity of atomic power that may be developed within our life time, however, would produce enough radioactive waste products within a year to make a detectable change in the ocean, even though they were uniformly distributed from shore to shore. Successive accumulations, year after year, would have an unpredictable influence on the whole biological cycle of the sea. This problem cannot be solved by hope and guesswork, for an error made now could have far-reaching effects on future generations.

Bostwick H. Ketchum
at Diamond Jubilee Semi-Annual meeting, A.S.M.E.

Immediate Employment Not the Goal

It is clear that institutions are not stimulating a sufficiently large percentage of their top undergraduates to consider graduate study as a normal step

(*Continued on page* 24)

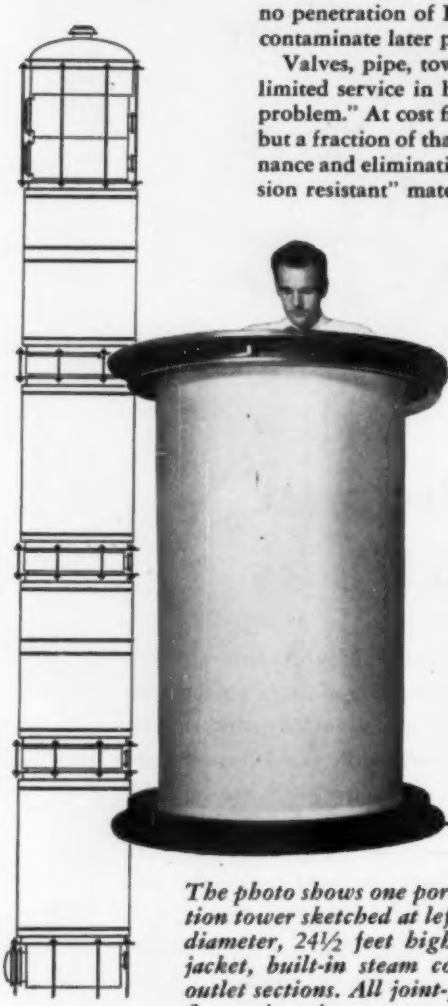


Get Improved Performance
in Process Equipment
by Clean Separation
between Vapors and Liquids
with YORKMESH DEMISTERS
Yorkmesh Demisters are answering Chemical Engineers demands the world over for a simple means of improving the performance and increasing the capacities of process equipment handling vapor and liquid materials.
• Higher vapor velocities can be used.
• Overhead product quality is improved.
• Entrainment losses are eliminated.
• Overall operating efficiency is improved.
• Easily installed in existing or new equipment.
For use in:
Vacuum towers
Distillation equipment
Absorbers
Scrubbers
Separators
Evaporators
Knock-out Drums, etc.
Prompt shipment in:
Monel, Nickel
304-316-430
Stainless Steels
Carbon Steel
Copper, Aluminum
Inconel and
Other Alloys
How YORKMESH Demisters work inside Vacuum Towers
Vapor disengaging from liquid creates fine liquid droplets which are carried as entrainment by the vapor stream.
The liquid droplets impinge on the fine wire surfaces of YORKMESH, and are coalesced into large drops which run down and fall off the YORKMESH.
The vapor is now dry. It has been entirely freed from entrained liquid. Thus a clean gas-oil goes to the catalytic cracker.
3.
2.
1.
Write for new Catalog 13 for complete information and engineering data on YORKMESH Demisters.
OTTO H. YORK Co., INC.
8 CENTRAL AVE.—WEST ORANGE, N. J.

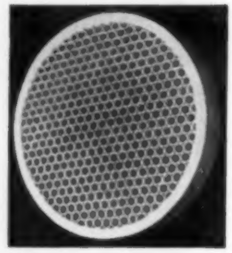
Lapp CHEMICAL PORCELAIN

Chemical inertness to acids of all concentrations is a characteristic of porcelain. And, as made by Lapp, it is pure, dense, hard, close-grained, homogeneous and *non-porous.* This means there can be no penetration of Lapp Porcelain—no crumbling from capillary pressures—no absorption of liquids to contaminate later processing.

Valves, pipe, towers, and special shapes of Lapp Chemical Porcelain are operating with almost unlimited service in hundreds of installations where "no other material would ever handle the corrosion problem." At cost figures that set records for economy, too. For Lapp Chemical Porcelain equipment costs but a fraction of that for special alloy and lined equipment—and quickly makes up, in reduced maintenance and elimination of need for replacement, the difference in its initial cost over that of cheaper "corrosion resistant" materials.



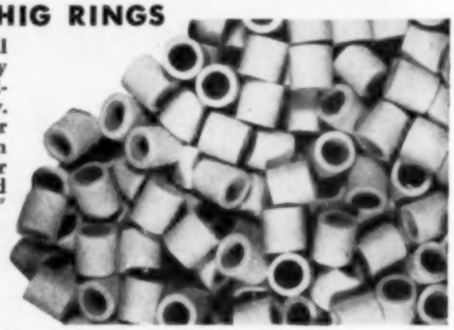
LAPP PORCELAIN CHEMICAL TOWERS AND TOWER PLATES



For distillation, absorption, fractionation ... or any process where liquids and gases must be tower-processed—towers of Lapp Porcelain assure long life, non-corrosion and purity of output. These towers are made entirely of porcelain (except for externally attached hardware, armor, steam-heat piping, jacketing, etc.). They can, on specification, be supplied with polished optically-flat joint faces for assembly without gaskets.

The Lapp Porcelain ring support plate is built of contiguous thin-walled glazed porcelain tubes, permanently compressed and fused in a heavy outside porcelain ring. It provides almost twice as much free space as conventional drilled or slotted plates.

LAPP PORCELAIN RASCHIG RINGS



Lapp Raschig Rings are of solid Chemical Porcelain, completely vitrified, strictly non-porous and iron-free. Inert chemically, they offer an indefinite life chemically. Physically, Lapp Porcelain is tougher against the abuse of tower operation than most of the regularly used tower packings. "Standard" rings ⅜" to 3" and heavy-duty partition rings 3" and 4" available from stock.

The photo shows one porcelain section of the Lapp absorption tower sketched at left. This tower, 26 inches in inside diameter, 24½ feet high, is provided with an insulated jacket, built-in steam coils, Tufclad-armored dome and outlet sections. All joint-faces are polished to an optically flat surface for vacuum tight assembly without gaskets.

LAPP PORCELAIN VALVES AND PIPE

The dependability and long life of the Lapp Valve, attested by successful installation in hundreds of chemical processes, is due to its sound design and the fact that it is made of *porcelain*—body, plug and packing rings. Y-valves and angle-valves ½" to 6", plug cocks, safety valves, flush valves, pipe and fittings ½" to 8".

LAPP TUFCLAD ARMOR

Security and safety of plant and personnel are assured with use of Lapp Porcelain with Tufclad armor—multiple layers of woven fiberglass impregnated and bonded to the porcelain with an Epoxide resin. Armor will hold operating pressures against gross leakage, even though porcelain body is damaged by impact, thermal shock, explosion or fire.

BOOTH 814 . . . Chemical Show

WRITE for description and specifications of Lapp Porcelain processing equipment. Lapp Insulator Co., Inc., 148 Wendell St., Le Roy, N. Y.

Lapp PULSAFEEDER

PISTON-DIAPHRAGM CONTROLLED-VOLUME PUMP

NO STUFFING BOX . . . NO LEAKAGE

Basic feature of Lapp Pulsafeeder design is its combination of reciprocating piston action (to provide the accuracy of positive displacement) with a hydraulically balanced diaphragm which isolates material being pumped from working pump parts—and, of course, eliminates need for stuffing box or running seal.

Control of pumping rate is achieved at constant pumping speed; variable flow results from variation in piston stroke length—adjustable by hand-wheel, or, in Auto-Pneumatic models, by instrument air pressure responding to any instrument-measurable processing variable.

In general, use of the Lapp Pulsafeeder is indicated for continuous (or intermittent) pumping, at accurately controlled volume, of fluids which cannot be safely exposed to conventional pistons, cylinders and stuffing box packing—because of the corrosive action of chemicals being handled and/or need for protection of product against contamination.

To meet the varied demands of low-viscosity liquids, high-viscosity liquids, slurries and gases, liquid-handling heads and valves are offered in a variety of materials and designs.

Lapp Auto-Pneumatic Pulsafeeder—responds to pneumatic instruments

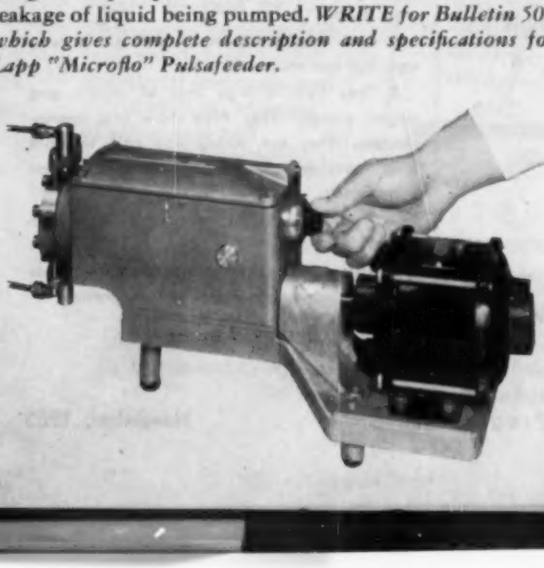
WRITE for Lapp Bulletin 440 which shows typical Pulsafeeder applications and flow charts, and which describes and lists specifications of models over a wide range of capacities and constructions. Lapp Insulator Co., Inc., 148 Wendell St., Le Roy, New York.

NEW "Microflo" Pulsafeeder

for precision pumping at micro flow rates

The "Microflo" Pulsafeeder brings the Pulsafeeder principle of controlled volume pumping to research applications, pilot plant and production line use which require precise pumping, metering of fluids, chemical feeding, sampling, proportioning and filling at micro flow rates. "Microflo" Pulsafeeder employs the same proportioning pump design features of the PULSAFEEDER—has no stuffing box, permits no leakage. Maximum flow of 2150 ML. per hour, at 1000 psig. Lapp "Microflo" Pulsafeeder assures years of dependably accurate pumping with no danger of pump failure, corrosion, contamination or leakage of liquid being pumped. *WRITE for Bulletin 500 which gives complete description and specifications for Lapp "Microflo" Pulsafeeder.*

Lapp Pulsafeeder with non-metallic liquid end, ball valves



Lapp

PROCESS EQUIPMENT

NOTED AND QUOTED

(*Continued from page* 18)

in professional education. . . . The upper fraction of undergraduates should be told that the best advanced education for the differing functions of engineering is that which will develop the intellectual capacity of the individual rather than high specialization toward a given functional objective. They also should know that in graduate study the student takes the initiative to work on his own as a full-fledged partner without undue assistance and that the best graduate education is custom-tailored to the individual student. These concepts will challenge the sharpest minds. But, of course, unless stipends of fellowships and assistantships are brought in line with advancing engineering salaries and with the fact that more and more graduate students have dependents, many and perhaps most of the best minds inevitably will be channeled into immediate employment. Finally, industry must be made aware that it has a very great stake in increasing the number of graduate students even at the loss of immediate employees and at the cost of competitive graduate or research fellowships that only it can provide.

L. E. Grinter,
Mechanical Engineering

Developing Creativity in Down-the-Line Executives

One of the needs of business is to bring up the creative power of second-line executives. They sit in plenty of conferences, but are too often tempted to use their imaginations merely to anticipate how their associates will react. Such anti-creative tendencies can often be overcome by active encouragement on the part of those at the top.

The eight outstanding characteristics of people with outstanding achievement records are:

1. They can get along with other people. They can see and understand people objectively. They deal with them impersonally to accomplish goals.
2. Their intelligence level is well above average, but not necessarily tops.
3. They have a high level of psychic and mental energy. They have drive and aggressiveness. They are willing and able to work long hours with intense concentration to get things done.
4. They want to be better than their competitors.
5. They have innate ability to explain ideas simply in words that others can understand.

(*Continued on page* 28)

Corrosioneering News

Quick facts about the services and equipment Pfaudler offers to help you reduce corrosion and processing cost.

Published by The Pfaudler Co., Rochester, N.Y.

WORLD PREMIERE . . .

1955 Chemical Show sees debut of several New Achievements in Glassed Steel Construction

No contamination, no leakage with new seal for reactors

No metallic contamination of your product. No stray, unwanted catalysts. No escaping vapors.

These are the advantages of a new nonmetallic rotary Crane-type seal now available on Pfaudler glassed or stainless steel reactors up to 100 gallons. (A similar design is also available for larger units.)

Only Pfaudler glass, Teflon, ceramic and carbon come into contact with your product. Design of the seal is simple, easily maintained.

New development boosts corrosion resistance of columns

Better results from fractionation and other processes requiring a column are now possible with the added corrosion resistance of a new Pfaudler development.

It's a glassed steel distributor plate, available for all size columns. Using Pfaudler acid-alkali-resistant glass, this plate provides complete flexibility of use over a range up to pH 12 at 212° F.

The corrosion resistance of this glass protects product purity, simplifies cleaning, and protects your equipment investment.

Dryer-blender tumbles out 4 days' work in 7 hours

In actual use, a Pfaudler glassed steel conical dryer-blender is producing as much dried product in 7 hours as formerly required at least 4 working days, using a different type of dryer.

Double-cone shape, tumbling action and efficient heating design are responsible for this great speed. In addition, a broad range of corrosive applications is possible, because the unit is fabricated of Pfaudler's special acid-alkali-resistant glassed steel.

To pre-test your product in the Pfaudler dryer-blender, a small 2'-diameter test model is available. You'll see it at the Chem Show – or write us for full details.

New Pfaudler hydraulic drive and seal

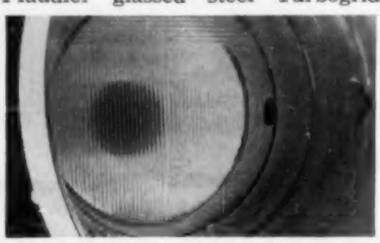
The new Pfaudler hydraulic drive and seal offers many advantages: It can be made in both stainless steel and glassed steel construction for a large range of reactor sizes and for greater horsepower requirements with either hydraulic or air motors.

Any noncorrosive fluid can be used as a seal – even one of the ingredients of your own product – providing you 100% protection against contamination.

This seal is operated under pressure, requires a minimum of maintenance, and is designed to give years of trouble-free service. Your Pfaudler representative can provide full details at your request.

New Turbogrid tray gives higher yield at lower cost

You're looking down the throat of a Pfaudler glassed steel Turbogrid



column, at a new tray design that provides enormously high capacities, yet lowers the cost of the column itself.

The tray is constructed of high-strength PYREX brand glass tubes,

Cutaway column, providing an unusual view of the "business side" of Pfaudler glassed steel construction, is a feature attraction at Chemical Industries Exposition, Philadelphia.

with all their inherent advantages of corrosion resistance, physical toughness, and thermal shock resistance.

Because of the high capacity resulting from this design, the column itself can be of smaller diameter than previously required – an important means of cutting its cost.

Now—variable agitator speeds ranging from 60 to 340 RPM

Six different agitator speeds: 60, 90, 120, 175, 250, and 340 RPM are now available on Pfaudler reactors up to 100 gallons.

These are made possible by interchangeable constant-speed sheaves of the new PW drive. As an alternative, variable pitch sheaves may be supplied, giving quick adjustment for *all* speeds ranging from 60 to 300 RPM.

The new PW drive rides high above the top head of the reactor, out of the way so you can have easy access to other nozzles.

Write for Bulletin 923.

Which material of construction for you?

Glassed steel, stainless, titanium, Inconel, Hastelloy, copper and copper alloys, and many other corrosion-resistant materials are commonly used by Pfaudler to solve processing problems. Write today for free, unbiased analysis of *your* problem.

NOTED AND QUOTED

(Continued from page 24)

6. They have self-reliance. They have no doubt of their own abilities to do a job and do it well.

7. They possess empathy. They have sensitivity to the ways others feel about things and the way in which other people think. Empathy is not to be confused with sympathy. Empathy indicates understanding but not necessarily agreement.

8. They possess "closure" ability. This is the ability to bring apparently unrelated things together conclusively to form a distinct solution or picture. That is, they can see the forest instead of the trees.

Charles N. Kimball
"Motivation Behind Accomplishment"

A Machine—Boon or Bane

The artificial kidney is another example of a machine that has saved so many lives that a whole rash of models has appeared, each skinning the cat in a different fashion. Each device is the goal of an ill-conceived engineering project. All ignore the fact that further clinical effectiveness depends upon the development of a better dializing or filtering interface, rather than cuter ways of leading blood through a cellophane tube.

Carl W. Walter
at Diamond Jubilee Semi-Annual meeting, A.S.M.E.

Engineers in Demand

One of our large and great universities, enrolling more than 20,000 full-time students, this year will graduate six chemical engineers. Forty companies are trying to hire these six young men.

William C. Foster
Address at Second Annual Observance Chemical Progress Week

Engineers Must Live in the Realm of Ideals

In the ideal a chemical engineer must meet the following specifications:

He must be of curious and flexible mind. . . .
He must have courage to essay the new, and wisdom to do so safely . . . .
He must know the ways of men: they must be led to work his plant and buy and use his product.
He must know the ways of matter and of energy: he must turn them to the end he seeks.
He must know his industry . . . .
He must know how to get things done before the market for the product wanes; before the cost of doing eats the profit.
He must, at every functional level, be somewhat a business man: he must judge markets and costs, taxes and tariffs.
He must be literate: without ability accurately to understand the words of others and to make his own ideas correctly known his usefulness is negligible or even negative.

(Continued on page 34)


OUT
IN
wherever precise flow measurement is critical . . .
Potter TURBINE TYPE FLOWMETER
ACCURATE, DEPENDABLE POTTER FLOWMETERS are being specified by more and more chemical processors each year for jobs that demand high reliability, high precision, low maintenance, extreme control precision. Available in sizes from 1/8" to 6" units, they measure caustics, acids, corrosives, unstable compounds, suspensions, super-refined liquids and other hard-to-handle liquids at temperatures up to 1200°F and at pressures to 35,000 psi. Easily incorporated into complex control systems because of their linear output, Potter sensing units produce a signal that can be telemetered, fed into digital information handling systems, or measured directly to indicate or control flow rate or total flow.
Find out how this unique approach to flow measurement can help solve your flow-control problems. Write for Bulletin S-1.
POTTER AERONAUTICAL COMPANY • Route 22 • Union, N. J. • Phone MUrdock 6-3010
Makers of "Potter Engineered" products


We've used "KARBATE" equipment for years and we're still finding places where it pays off!
Many users of "Karbate" brand impervious graphite process equipment originally installed it where nothing else would work — then went on to extend its use to other, less severe, process-unit locations. A job doesn't have to be a major headache for "Karbate" equipment to pay off. *Wherever* corrosive conditions exist, consider "Karbate" impervious graphite and "National" carbon and graphite. You'll be pleased with the economies they offer.
10 PAY-OFF FEATURES OF "KARBATE" BRAND IMPERVIOUS GRAPHITE PROCESS EQUIPMENT:
Low first cost
Extended low maintenance
Corrosion resistance
Immunity to thermal shock
No metallic contamination
High thermal conductivity
Workability — readily fabricated and serviced in the field
Sturdy, durable constructions
Standard stock units
Complete technical service
Manufactured only by
NATIONAL CARBON COMPANY
The term "Karbate" is a registered trade-mark of Union Carbide and Carbon Corporation
NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N.Y.
Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco
IN CANADA: Union Carbide Canada Limited, Toronto
Pumps—Catalog Section S-7250
Pipe and Fittings—Catalog Section S-7000
Heat Exchangers—Catalog Sections S-6740 and S-6840
Cascade Coolers—Catalog Section S-6820
HCl Absorbers—Catalog Section S-7480

NOTED AND QUOTED

(*Continued from page* 28)

He must live engineering ethics, fully accepting responsibility to the public for sound and reliable performance . . . .

Ideals these statements may be, but one will find among successful chemical engineers few far deficient with respect to many of them.

Thomas B. Drew
Columbia Engineering Quarterly

MARGINAL NOTES

A.S.M.E. Standard on Industrial Engineering Terminology. American Society of Mechanical Engineers, New York (1955), 50 pages, $1.50.

This is a handy 50-page compendium of 500 industrial engineering terms arranged in alphabetical order with definitions as brief as practicable and easily understood even by nonexperts in the field. This work fills an important place in the well-known series of A.S.M.E. Codes and Standards for safe construction, operation, and testing of elevators, boilers, piping and screw threads.

Elements of Food Engineering—Volumes II and III. Milton E. Parker, E. H. Harvey, and E. S. Stateler. Reinhold Publishing Company, New York (1954), Vol II, 360 pages $8.50, and Vol. III, 241 pages, $6.75.

Reviewed by A. W. De Vout, Swift & Company, Chicago, Illinois.

These two books complete the three-volume series on the "Elements of Food Engineering." They discuss the preparation, processing, handling, and packaging of foods from the unit-operation and unit-process viewpoint.

Volume II covers such operations as: (1) assembly of raw materials with emphasis on material handling and grading, (2) preparation of raw materials with reference to cleaning, separating, disintegration, and pumping, and (3) conversion of raw material, with chapters on mixing and heat transfer.

Volume III continues the discussion on raw material conversion, with chapters on evaporation and distillation, drying and dehydration, and control procedure. This volume also contains a section on the treatment of the final product centering on forming, coatings, packaging materials, and packaging methods.

(*Continued on page* 39)

MARGINAL NOTES

(*Continued from page* 34)

In their treatment of their subject the authors attempted an ambitious program. The books are literally jammed with an enormous amount of information on the preparation, processing, and handling of various foods. Practically every food process and every type of equipment used therein is described or touched upon.

Because of the broad scope of the subject, it is unfortunate that discussion on each process and each piece or type of equipment had to be brief. For the same reason the books include comparatively little engineering data that would aid a process engineer to design or select the right equipment for a working plant. This series of books could serve as an introduction or the initial steps to the study of what the authors call the new profession of food engineering.

In reviewing these books, no errors of fact were detected, which, in itself, indicates the large amount of effort and care the authors exercised in their preparation.

The Prevention of Occupational Skin Diseases. Louis Schwartz. Association of American Soap & Glycerine Producers, Inc., New York (1955), 42 pages.

Prepared especially for industrial management and for those charged with public health and safety, this booklet describes occupational skin diseases and their prevention. The story begins with the incidence of occupational dermatoses, discusses the anatomy and physiology of skin and its appendages, cites the causes and prevention of occupational dermatoses, and lists the basic requirements of industrial skin cleaners. Preventive measures include the elimination of irritant chemicals; good housekeeping, protective clothing, protective ointment, and personal cleanliness are essential.

Tables and Data. United States Testing Company, Inc. Hoboken, New Jersey (1955), 112 pages, illustrated.

To commemorate its seventy-five years of service, the United States Testing Company has come out with another revision of the booklet containing data and tabular matter used extensively by dyers, textile mill operators, and others. The Table of Contents reveals a thorough coverage of the following fields: chemical and physical, engineering, plastics, leather, textile, psychometrics, and bacteriology. Included in the Chem-

(*Continued on page* 40)

MARGINAL NOTES

(*Continued from page* 39)

ical and Physical Tables is a short list of important chemical and physical definitions, and in the engineering classification are many tables on metals—physical properties, weights of various materials, etc.

Units of Weight and Measure—Definitions and Tables of Equivalents. L. V. Judson, National Bureau of Standards Miscellaneous Publication 214, Government Printing Office, Washington 25, D. C. (1955), 64 pages, 40 cents.

This publication, superseding Miscellaneous Publication 121 issued in 1936, defines the units of length, mass, area, volume, and capacity in use in the United States. It also gives tables of interrelation and tables of equivalents for these units in the metric system and in the U. S. customary system. Conversion tables are confined to simple units, excluding all compound units such as foot-pounds, pounds per cubic foot, and feet per second.

The publication should prove useful in scientific, industrial, commercial, and other fields.

Synthetic Rubber. G. S. Whitby (editor-in-chief). John Wiley & Sons, Inc., New York (1954), 1,044 pages, $18.00.

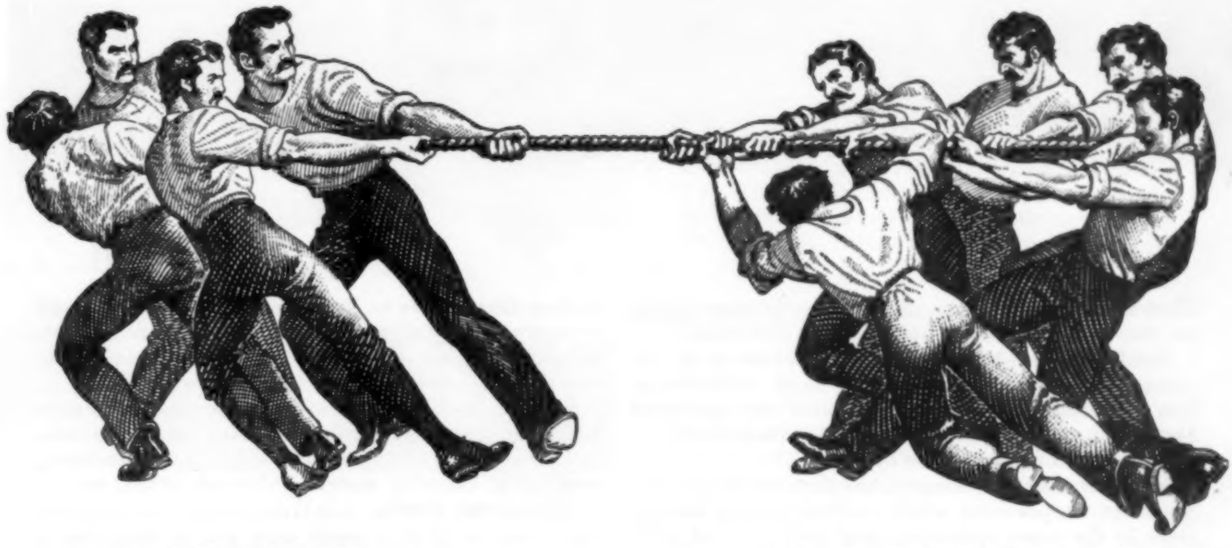
Reviewed by W. M. Otto, Firestone Tire & Rubber Company, Akron, Ohio.

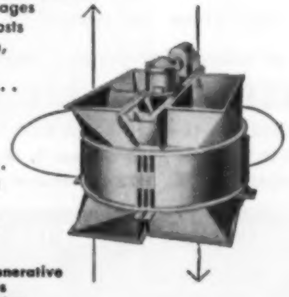
Thirty-eight authors combined their efforts to produce an authoritative description of the theory, raw materials used, production, physical properties, and end-uses of the various types of synthetic rubber in production today. Each chapter is written by an outstanding authority in his particular field, so that the book as a whole is a fine addition to chemical engineering literature. The work, which summarizes the developments in all fields of synthetic rubber from their earliest beginnings to the conclusion of the Government-sponsored program in the United States, was prepared under the auspices of the Division of Rubber Chemistry of the American Chemical Society.

Although much of the information contained in the twenty-six well-written chapters complete with photographs, flow diagrams, tables of data, and graphs has been available to technical people within the synthetic rubber industry, only a small fraction of it has been published in technical publications.

An interesting style coupled with excellent organization makes this book of

(*Continued on page* 44)





MARGINAL NOTES

(*Continued from page* 40)

value both to the researcher concerned with fundamental theory, polymerization methods, and physical properties and to the engineer interested in equipment and methods of production. The introduction and historical review present a preview of the many fine chapters to follow. Methods of production of the monomers are described fully. The manufacture of GR-S synthetic rubber, its processing and compounding, and the physical test methods for polymer evaluation give the story of the large-scale general-purpose rubber with sufficient attention to details to make the material of value to the rubber chemist, compounder, or student. The book is made complete by the addition of an excellent chapter covering German synthetic rubber developments.

A thorough author and subject index, together with the reference list at the end of each chapter, facilitates the use of this book. It is recommended to the chemist and chemical engineer interested in any phase of research, development, or production related to synthetic rubber.

BOOKS RECEIVED

The Humanistic-Social Stem of Engineering Education. The Cooper Union. New York, Engineering and Science Number 33 (June, 1955), 56 pages.

A revised and enlarged edition of a classified bibliography compiled by The Cooper Union Library.

Conference Proceedings. Professional Development—The Responsibility of Industry and the Engineer. Sponsored by National Society of Professional Engineers in conjunction with its 21 annual meeting (June 2, 1955), 56 pages, $2 for N.S.P.E. members and $4 for nonmembers.

A complete transcript of the conference held in Philadelphia on professional development is now in booklet form.

The Quantitative Analysis of Drugs. 2 ed. D. C. Garratt. Philosophical Library, Inc., New York (1955), 670 pages, $17.50.

Electro-Magnetic Machines. R. Langlois-Berthelot. Philosophical Library, New York (1955), 535 pages, $15.00.

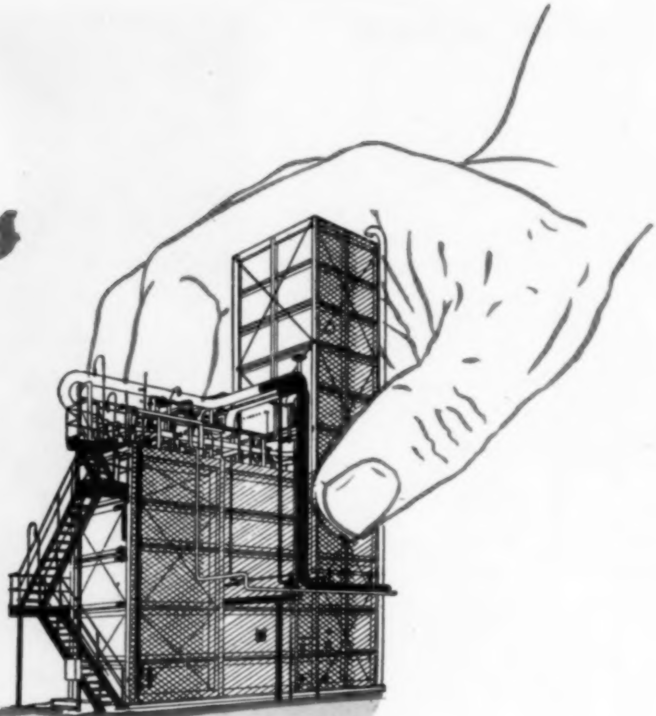
Qualitative Organic Analysis and Scientific Method. Alexander McGookin. Chapman & Hall, Ltd., London and Reinhold Publishing Corp., New York (1955), 155 pages, $4.50.

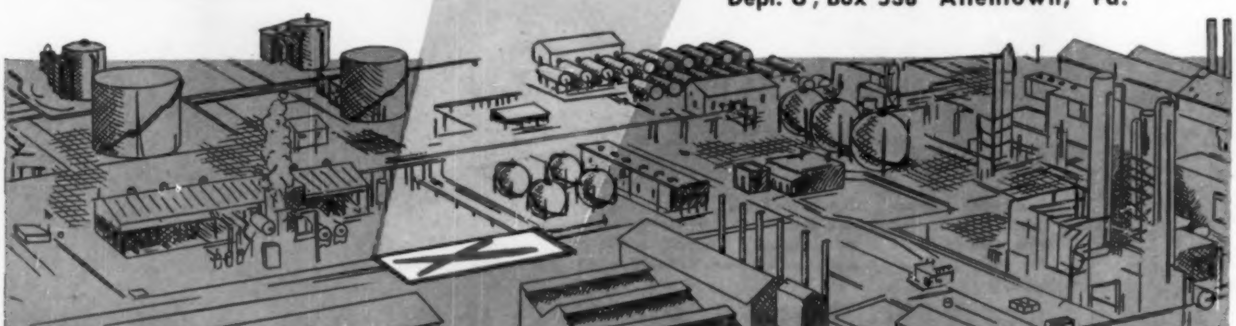
Nickel in Iron and Steel. 2nd in series of Alloys of Iron Research Monographs. A. M. Hall. Published for The Engineering Foundation John Wiley & Sons, Inc., New York, and Chapman & Hall, Ltd., London (1954), 595 pages, $10.00.

The Hard-Surface Floor-Covering Industry. R. J. Lanzillotti. State College of Washington Press (1955), 204 pages, $4.00.

Steam, Its Generation and Use, 37 ed. The Babcock & Wilcox Co. George McKibbin & Son, New York (1955), $10.00.


B-P
mixers
designed and
built for
maximum efficiency
regardless
of product
See us at Booth 540-544 at the
CHEMICAL EXPOSITION
SEE OUR EXHIBIT
PHILA
EXPOSITION CHEMICAL INDUSTRIES
Typical of the high-production, cost-cutting
Baker Perkins chemical processing equipment is this Universal Vacuum
Mixer, size 15 TWEM. Working capacity 100 gallons; total 175 gallons.
Constructed of Stainless Steel, jacketed for 125 psi heating or cooling.
BAKER PERKINS INC.
Chemical Machinery Division • Saginaw, Michigan
326





CEP trends / SYNTHETIC RUBBER BOOM

Almost as soon as industry took over the government-owned synthetic rubber plants there was a rush to expand capacity to keep pace with the rapidly growing demands of the tire industry, to lay the groundwork for meeting anticipated future demands.

Both the government and the rubber industry are known to be concerned about adequate supplies of natural rubber, concentrated in the politically uncertain East. Also, natural rubber now costs about twice as much as synthetic.

Of course, synthetic rubber is not a complete substitute for tree rubber, especially in heavy duty truck and air plane tires, which is the main supplies of the natural product. Still, bigger reason for the worry about long range strategic synthetic production will be a major help.

Expansion

The rubber industry, which is now operating most of the synthetic GR-S capacity, is talking of expanding current production of about 900,000 tons a year by another 500,000 tons in the next four years or more. This is expected to cost in the order of $200 to $300 million. On top of this there will undoubtedly be important expansion later on in new types of synthetic rubber and in compounds not strictly in the rubber group which may compete with rubber for some uses.

World consumption of natural and synthetic rubber is expected to be around 2,800,000 tons this year, about 1,800,000 tons tree rubber, the balance, mostly produced in this country, synthetic. United States consumption of both types of rubber in the first eight months of this year was up to 1,900,000 tons, 28% of the same 1954 period. Consumption of synthetic was up over 35%. Meanwhile natural rubber output has been lagging slightly behind consumption, although the stocks on hand in the East of over 800,000 tons are substantial.

The evidence seems clear that the American chemical industry, of which the rubber industry can now be considered a division, is getting set to free itself from dependence on the natural raw material as soon as it economically can. This is a simple matter of economics. Industry in the United States has been harried in former years by wide price swings in natural raw materials, creating serious and often dangerous inventory problems.

The rubber industry, which now uses about 60% synthetic in its operations, may be said to be about at the half-way mark in its efforts to be relieved of dependence on tree rubber. But this is, of course, contingent on the successful production of real substitutes for tree rubber.

Contenders

There are at least two major candidates on the horizon for "Synthetic" natural rubber. Goodrich-Gulf Chemicals, Inc. affiliate of B. F. Goodrich Co. has a newly developed product said to be chemically and physically a reproduction of tree rubber. It has already been successfully tested on heavy truck tires and can be sold at prices competitive with tree rubber this year. A pilot plant is now being built and larger capacity is planned within a few years more. Firestone's entry is said to be essentially the same as natural rubber, has been in pilot plant over two years with 500,000 miles of tire tests already made.

Then there are the isocyanate or urethane rubbers made by a number of important chemical firms including Du Pont and Allied Chemical & Dye Corp. Du Pont which calls its product Adiprene B says that it has wearing properties superior to tree rubber which should make it excellent for tire treads when various technical problems can be ironed out, especially how to make 35 cents to 50 cents a pound urethane rubber adhere to less costly GR-S rubber. Work is being done on the problem by Firestone, Goodyear and other rubber companies.

Besides probable eventual uses in tire treads, the urethanes, still only in small scale production seem assured of very large markets in both hard and soft foams which can be used instead of rubber latex for mattresses, pillows and upholstery. Makers are talking hopefully of a 50,000 ton market for the materials.

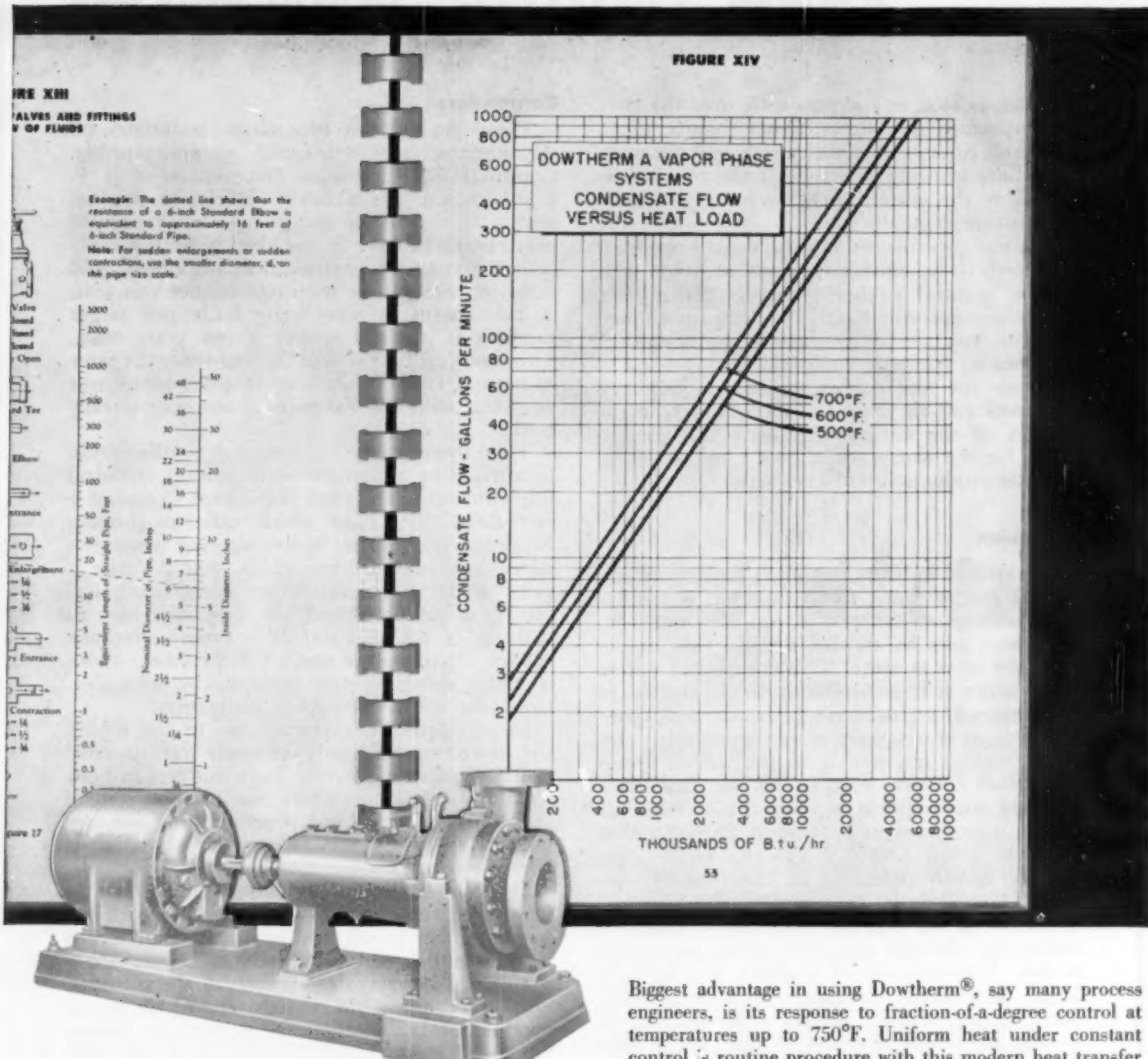
Du Pont has other contenders in the form of its old but still growing neoprene, first synthetic in the rubber group, and of its Hypalon, which is chlorosulfonated polyethylene. There are a number of other materials such as the silicones, vinyl compounds and polyethylene which in one way or another compete in parts of the rubber field.

Goodyear Tire is increasing its synthetic output at its Houston plant by about 50%. Half of this will be done by 1957 at a cost of about $6 million to be followed soon after by the balance of the program. The existing Houston facilities have already been increased about 35% to 137,000 tons capacity.

Firestone has improved efficiency of operations and has added new capacity to bring its Lake Charles plant to an output more than double the 1954 output of 63,000 tons.

Goodrich is spending $2,500,000 to double its output of special purpose Hycar rubber at Louisville, Ky. and is spending another $8,500,000 on an acrylonitrile plant at Calvert City, Ky. U. S. Rubber and other big firms have expansion plans in the works.

Control Problems In Process Heat?



DOWTHERM

responds with fraction of a degree control to simple pressure regulation!

Biggest advantage in using Dowtherm®, say many process engineers, is its response to fraction-of-a-degree control at temperatures up to 750°F. Uniform heat under constant control is routine procedure with this modern heat transfer medium.

Dowtherm provides low-pressure, high-temperature heat, extending the advantages of vapor-phase heating to much higher temperatures. The extraordinary thermal stability of Dowtherm makes it a natural for those applications demanding liquid phase heating.

Many process industries have developed new products or improved old-line products by utilizing the unique properties of Dowtherm. You'll find all the facts in the "*Dowtherm Handbook*", a valuable technical guide of process heat information. A request on your letterhead will bring it to you promptly. THE DOW CHEMICAL COMPANY, Midland, Michigan, Dept. DO 727A-2.

you can depend on DOW CHEMICALS

CEP

opinion and comment

TO THE FAIR WE GO

With the change of seasons bringing frost to dull the glint of morning sun off the hemispheroids, many of you must be shaping plans to go to the fair—the 25th Exposition of Chemical Industries, if you please. Most of us know it as simply the "Chem Show."

Conceived during the industrial hiatus of World War I, The Chem Show built its place in the American scene by simply making it easier for paper manufacturers to find out that sewage pumps might very well handle their pulps, or that dyestuffs manufacturers could benefit by using beer clarifying filters. Thus the great unification of the process industries got much of its early momentum from the show.

The situation changed rapidly with the founding of a chemical industry, which not only accelerated the general pace, but also brought about the development of equipment and materials for its own special needs. With Little's unit operations, the new type of engineer—the chemical engineer—was able to move with ease throughout the twenty-three process industries, adding the final touch to unification.

Today the show represents a comprehensiveness of display unmatched anywhere else in the world. Its very size has created problems, however, for the individual who wishes to "see it all," as anyone who has tried, knows.

Heartening is the development of better exhibits, noted especially during the past two shows. These exhibits reflect consideration for the capacity and patience of the viewer by making it easier for him to comprehend the increasingly complex themes involved. Often, these are based on truly mature technical themes, making the study of them a rewarding experience for the engineer.

In compiling returns of our preshow survey of subjects and literature (for preparation of the Data Guide appearing in this issue) those exhibits which seemed to be of more than usual engineering interest were so indicated. Your attention is invited to these with the caution that it was impossible to assemble all pertinent information.

We will be at the show looking for exhibits of unusual engineering interest for a report to appear in January, C.E.P. Readers' comments on exhibits, either verbally at the show or by letter, will be helpful.

Exhibits of full-scale plant equipment are often of interest to plant engineers. Perhaps not too well known is the fact that some of what is on display will have been custom-built, and will be delivered and installed immediately after the big show closes. Actually, a surprising amount of equipment on display is built to average specifications, with the hope that it can be sold during its exhibition. If in the market, why not pocket an order blank before leaving home? How better to impress the boss than to bag a badly needed item, while on a Philadelphia safari?

J.B.M.

POWELL VALVES . . . THE COMPLETE QUALITY LINE . . . POWELL VALVES

. . . THE COMPLETE QUALITY LINE . . . POWELL VALVES . . . THE COMPLETE QUALITY LINE . . .

. . . THE COMPLETE QUALITY LINE . . . POWELL VALVES . . . THE COMPLETE QUALITY LINE . . .

Preferred for Precision and Performance

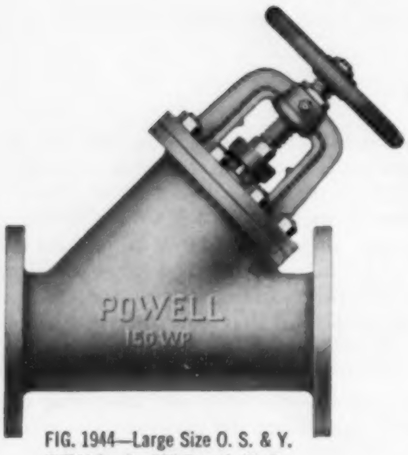


FIG. 1944—Large Size O. S. & Y. "Y" Valve for 150 Pounds W. P.

Powell Valves are the choice of engineers because they know every valve is precision made, meeting every specification—every time.

And there are other good reasons why engineers prefer Powell Valves—because Powell Valves are dependable . . . economical . . . and Powell has the COMPLETE quality line of valves.

Consult your Powell Valve distributor. If none is near you, we'll be pleased to tell you about our complete line, and help solve any flow control problem you may have.

The Wm. Powell Company Cincinnati 22, Ohio... 109th year

Visit our Booth No. 48 at the Exposition of Chemical Industries at Philadelphia December 5-9

FIG. 1891—Flanged End Liquid Level Gauge. Offset pattern.

FIG. 2433SS—Stainless Steel Bolted Cap Swing Check Valve for 150 Pounds W. P.

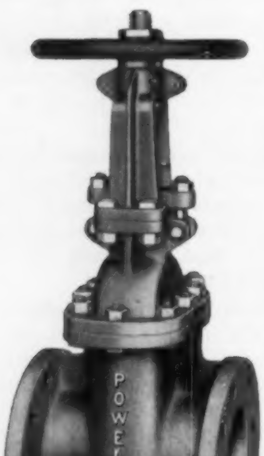
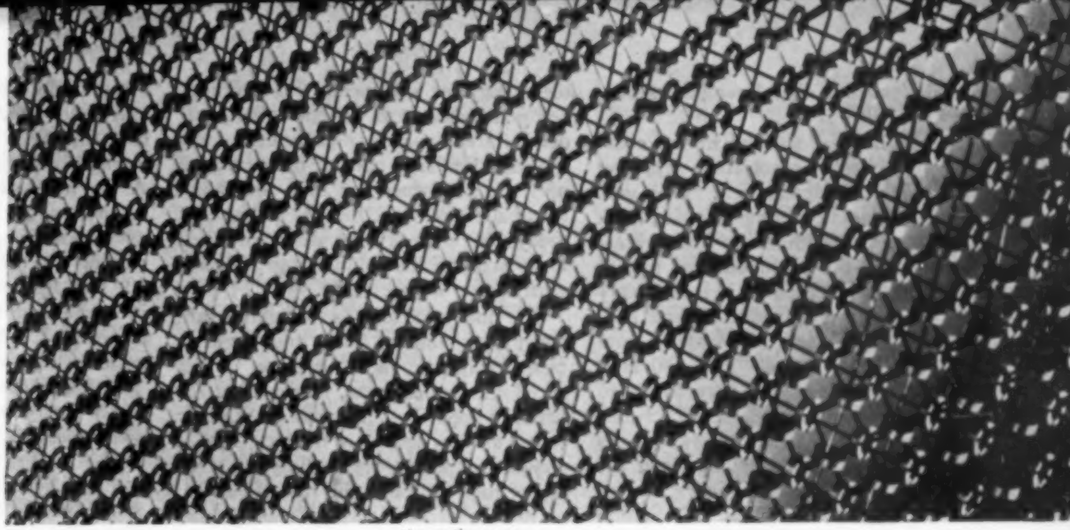


FIG. 2453G—Stainless Steel O. S. & Y. Gate Valve for 150 Pounds W. P.

POWELL VALVES



Magnetic cores.

THE FUTURE OF automatic information handling IN CHEMICAL ENGINEERING

Charles R. DeCarlo

Applied Science Division,
International Business Machines Corporation, New York

The last decade has witnessed the emergence and development of two technologies, both of which have affected and will continue to affect profoundly the world in which we live. These are (1) nuclear power with all its military, political, and industrial implications, and (2) high-speed electronic-switching devices, of which the most important and dramatic manifestation is the automatic electronic computer.

Norbert Wiener (*5*) pointed out that the first Industrial Revolution was a revolution of power—the replacement of man's muscles with machines—whereas the second industrial revolution will be one of communication—the replacement of some of man's thinking and control functions by machines. This is certainly an irrefutable statement to which, however, should be added the fact that the development of nuclear power adds a new and revolutionary dimension to former concepts of power engineering. Whether these developments are revolutionary may be an academic question, but certainly they do characterize the technological frontiers of today's society. These parallel and interrelated technologies are affecting every branch of modern engineering. Undoubtedly the chemical engineer of tomorrow will play a major role in the development of nuclear reactors, automatic process plants, and the many other fruits of these technologies.

This paper discusses the use of one of these technologies–electronic switching–and particularly the automatic computer, as it has and will be used by the chemical engineer. A characteristic of this field is that it concerns the design, prediction, and control of processes which are self-contained with respect to energy and material considerations. In this concept of a broad engineering area, the electronic computer has been, and will continue to be, an important tool and instrument.

The Nature of Computers

A brief description of the nature of the automatic electronic computer and its uses is in order. The typical automatic electronic *digital* computer consists of several basic functional units. These are:

1. input
2. output
3. storage
4. arithmetical and logical units
5. control units

A fundamental notion involved in the digital computer is that information can be represented as a series of discrete bits. These bits may be assembled in a wide variety of codes such as standard Morse code, binary coded decimal representation, or pure binary. Information thus coded can be converted into electronic pulses and the electronic pulses can be transmitted, stored, and operated upon for the purpose of computation or control. Thus, all automatic digital computers are in essence vast switching networks. Today, computers are designed with switching times of the order of a million times per second and the computers of the future will certainly be many times this rate.

Storage—Basic Element of Computer

The heart of the large electronic computer is its high-speed storage system. There are several commonly used storage devices in today's computers. These are:

1. magnetic cores
2. cathode ray tubes
3. mercury delay lines

Of these three, the magnetic core storage seems to hold the most promise.

As magnetic cores are used in I.B.M. computers today, information is randomly available from storage within nine millionths of a second. This means that the arithmetical and logical unit can consult the main storage more than one hundred thousand times per second. The current size of magnetic core memories ranges from forty thousand decimal digits (4,096 36-bit words) to more than 320,000 decimal digits. In this high-speed storage would be stored the numbers and information required to perform a particular calculation or design for analysis, as well as the procedure to be followed in making the analysis. The storage of both data to be operated upon and the procedure for operation in the same high-speed memory are the characteristics of a class of machine called "stored program." These are the most ad-

vanced electronic digital computers currently available.

The high-speed storage in the computer is directly associated with the arithmetic and logical unit. This unit performs a function of comparison, logical choice, and arithmetic. The operating speeds of the arithmetic and logical units in today's computers are extremely fast. For example, additions and subtractions can be performed at the rate of 250,000 to almost 1,000,000/min. Multiplication times can vary 50,000 to 240,000 a minute and logical decisions can vary from 500,000 to more than 1,000,000/min., all depending upon the particular type of computer in use (I.B.M. Type 705 or 704). Information is moved from the high-speed storage to and from the arithmetical and logical unit under the control of the control unit, which interprets information in the high-speed storage as either instructions or data. The arithmetical, logical, and storage-reference speeds of these machines seem incredibly high, but it should be remembered that in order to follow a particular problem it is necessary to define every logical step of the procedure into a primary set of operations which are wired within the machines.

Thus, in the engineering design of an electric power transformer, almost 10,000 operations are necessary to describe the process an engineer performs in evaluating a particular design. This particular design must be reevaluated with different parameters until some set of criteria is satisfied. Perhaps ten to thirty iterations may be required before a satisfactory design is obtained. Or, in the simulation of a typical refinery operation, some 30,000 program steps are necessary to describe the refinery technology for a particular set of crudes being analyzed as to various outputs under different operating parameters. An unbelievably large number of operations must be performed for each individual set of answers. It is for this reason that today's high-speed computers are taxed to do many of the engineering problems with which we are faced.

The input of today's computers are paper tape, punched cards, and magnetic tape. Magnetic tape, because of its speed and compactness, is becoming the primary input-output media. Magnetic tapes, as they are now used on I.B.M. computers, permit the reading and writing of information at the rate of 900,000 or more characters/min. This information can be read into the high-speed storage for processing by the arithmetic and logical unit. This is approximately seventy-five times as fast as information can be read from punched cards. The punched cards are normally read at the rate of 150 cards/min., eighty characters per card.

In general, punched cards are used to introduce original data and descriptions of procedures into the tape-processing system. After this step has been concluded, the magnetic tape then acts as the input to the main storage.

Magnetic tape and line printing are the main outputs of today's computers. Again magnetic tapes can write at the rate of better than 900,000 characters/min. Today's line printers operate at 150 lines/min. up to 1,000 lines/min.

An additional type of storage available is the magnetic drum. This is a device for storing information on the face of a metal cylinder in such a way that the information is available once each revolution of the drum to the arithmetical and logical unit. Magnetic-drum storage constitutes the main storage of the intermediate computers of today and also acts as an intermediate storage level in the larger computers. As the magnetic drum is used on I.B.M. computers as an intermediate storage device, it is capable of reading and writing information at the rate of 100,600 digits/sec. Such drum storage is invaluable for the manipulation of empirical or tabular data which so often occur in engineering analysis.

Another type of storage which has recently been announced is the large random access storage involving the use of magnetic discs. In this unit as announced by I.B.M., 5,000,000 digits are stored on the face of discs looking much like a juke box. Information is available at random in such a device within less than half a second. It appears certain that random access will be of great value in the solution of engineering design problems where a large amount of infrequently consulted data must be utilized in the preparation of analysis.

I.B.M. 702 electronic data processing machine.

How Computers May Be Applied

From the experience thus far gained, it now appears that the automatic electronic computer will influence the general field of process engineering in several ways. Among these may be included five major areas:

1. as a tool to be used in fundamental research
2. as an aid in chemical engineering design
3. as an aid in economic studies of process operations
4. as an aid to production management
5. as a principal component of automation

In each of these some progress has already been made.

FUNDAMENTAL RESEARCH

The electronic computer has been an invaluable tool in nuclear research. The modern electronic computer enables the solution of nonlinear hydrodynamic equations, problems in diffusion theory, and the application of Monte Carlo techniques. It is possible to combine equations representative of all three types into one over-all calculation of reactor parameters and thus use the computer as a mathematical model of the complete reactor.

This is particularly valuable when the reactor geometry is complicated. Here Monte Carlo methods can be employed to study the effect on criticality of cross section, energy-group variation, by-product poisoning, dimensional variation, and a host of additional variables. Importantly, these calculations may be done in three space dimensions and time. Thus the complete geometry of a reactor may be represented as it is, with-

out the inaccuracies inherent in a two-dimensional approximation. As the commercial development of nuclear power takes place, additional design criteria will be imposed, requiring even more analysis.

Because of its value as a tool in solving complex partial differential equations, the electronic computer will be important in the solution of many problems occurring in physical chemistry, particularly those involving phase-equilibrium phenomena. For example, recently there has been reported a solution of the problem of fluid flow through porous media, where the fluid is composed of several phases. In this instance it is not feasible to determine an analytic solution to the differential equations representing the flow, principally because the phases interact. However, it is possible to determine particular numeric solutions for a given set of parameters. Thus practical study can be made although no general solution exists.

Also in the area of fundamental research, the ability of the electronic computer to perform all the calculations normally associated with statistical methods will be of great importance in the future. Much of chemical research rests upon empirical work validated by correlation procedures. The statistical treatment of data has been one of the primary applications of the electronic computer. Actually, standard programs are available on most computers for regression analysis, least squares fit, variance analysis and other techniques.

DESIGN

Electronic computers have been used in the design of distillation equipment. In this application heat and material balances around each plate, as well as the procedures for adjusting the operating parameters, are written in explicit mathematical and logical form. Data are entered into the computer concerning the geometry of the equipment and material composition of the products involved. The computer then evaluates the behavior of the tower under a given set of conditions. At each stage of the computation the computer evaluates the design against some set of criteria, adjusting parameters according to the procedure in such a way as to improve the design. This is an example of simulation on a computer. By this is meant the condition wherein the computer simulates the behavior of a physical system. By an adjustment of the parameters under study, a system can be observed in operation under a wide variety of conditions. With this type of computer simulation the over-all design can be optimized.

Besides being an aid in designing new equipment, the electronic computer can be a valuable asset in evaluating modifications to be made to present equipment, where necessary, to provide better service. In this regard electronic computers are used by several oil companies. A typical fractionation problem would involve complex mathematical operations, simultaneous treatment of several components, and variation of catalytic feed rate as a parameter. Initial computation would now arrange a feasible operation. Following this, a series of pilot runs might be made and the computer used in the evaluation of the results of these runs.

ECONOMIC STUDIES

Perhaps the most intriguing application of the electronic computer in process engineering to date is in the area of management science. In this particular type of application an investigation is being made of a process to determine the most economic or optimum mode of operation. Typical examples of this occur in oil refineries where components must be blended into a variety of outputs. Generally, output mixtures must satisfy a set of specifications, such as 50% point, vapor pressure, octane ratings, and viscosities. In addition to this, a volumetric restriction might be imposed. For example, perhaps a certain minimum volume of a particular output must be produced. Certainly the input materials must satisfy also a set of restrictions such as the amount of each component available and technological specifications of the components. The problem is then to determine from the given resources and, subject to the set of specifications and restrictions, that operating practice which will satisfy all specifications, yield maximum profit or minimum cost, or some other measure of goodness. In this type of analysis, cost data are entered for the particular components used as input and price data are assumed as a measure of the output.

As part of the analysis a study may be made of the effect of price or cost changes in the operating conditions. It is possible to explore a wide range of the economic conditions after the technological model is once established on the computer. One of the mathematical frameworks upon which these problems are solved is that of linear programming. This method rests upon the assumption of linearity, that is, that the outputs are proportional to the input and that the specifications for the output can be stated as linear combinations of the input specifications. One might argue that the assumption of linearity is too severe a restriction to place upon the solution of a real physical problem. However, it is a first approximation to the physical problem and as such serves to give insight into the real problem. Even so, in batch processing, it appears that the linearity assumption is not completely unrealistic.

An interesting situation develops when such an input-output analysis is considered as embedded in a competitive environment. Assume, for example, two processing plants serving the same market, or at least markets which have common areas of overlap. Assume, also, that a certain product has become increasingly popular so that at a particular time neither processing plant can satisfy the market for this particular product. It may also be that other previously popular products have fallen into market disfavor and now constitute a surplus. If neither refinery were to increase its production of the popular product, this product could be shipped in from outside sources to satisfy the market. However, the problem is to determine how each processing unit should act. Assume that the first processing unit has four courses of action that it can take and by this action is meant a basic change in what the processing unit produces as its output. Each of these four changes, it can be assumed, has a

certain profit associated with it. If the second processing unit fails to take any action with respect to the popular product, the first processing unit can produce enough to satisfy the current market with a corresponding increase of profit. However, the second processing unit also has several courses of action available to it. Suppose, now, that the various choices of production schedules for each processing unit are listed. Then, these various production schedules can be taken in combination—one from each processing unit—and on the basis of the available market information each combination would have a certain profit associated to processing unit (1) and processing unit (2). Each combination could be called a strategy, that is, processing unit (1) action vs. the action of processing unit (2). If it is possible to list quantitative estimates for the values of competitive activity, then it is possible for the electronic computer to evaluate the combinations of strategies to determine the optimum strategy for each part. This concept of management strategy is admittedly abstract and much work must be done before such problems can have real meaning when referred to

corporate or human competitive activities.

However, there is a type of real problem where such a method of solution will be of value. This is the problem where the competitor is not a human competitor, but rather the world itself, that is, viewing nature itself, or those variables over which we, as the competitor, have no control. As an example of this, consider the problem which is inherent in practically every industry: the selection of optimum production rates and inventories to meet variable season requirements. In general, the market requirement of the product by time period can be displayed as a probability distribution. Thus in any one time period, nature has several strategies available as a result of the distribution of the product requirement about some mean value. Perhaps this distribution might be a function of daily temperature, as in the case of heating oils.

I.B.M. 705 magnetic core memory.

Assume that the producing unit has several allowable levels of production and inventory, and several allowable starting inventories for each product. The problem is then to determine the strategy which will optimize the profit for the producing unit against the variable season demand. This is a problem which has, and can be, solved on the electronic computer. This problem introduces an important concept—probability. For the optimum profit is in reality the optimum expected profit, where expectation has its usual mathematical connotation. This, again, illustrates one of the advantages of the use of the electronic computer. For only through the use of such a tool can problems involving stochastic variables, that is, variables dependent upon chance, be solved. In the problem cited the computer can actually generate within any one time period a random number, and use this number for consulting a probability distribution of market demand within the time period. This market demand can then be used in adjusting and determining particular production rates to be used during the time period which, in turn, will affect the available inventory at the end of the period.

A final example of the use of the electronic computer in evaluating economic choices concerns the problem in accurately describing the chemical process in such a way that no assumptions are made concerning linearity. What has been done is to describe as realistically as possible what takes place within the processing unit without regard to linear assumptions. This particular technology will involve much more than straight lines. Indeed, it will involve various curves and surfaces which, taken together, give the most complete and accurate statement of the technology of the processing unit. Having defined the engineering of the processing unit as completely as possible, the computer is operated with a set of data corresponding to real inputs. As a result of this analysis, it is possible to determine what particular type of outputs would be available with a given set of raw materials and a specified set of operating parameters. Also, operating conditions, temperature, pressures, etc., could then be varied to determine their effect upon output. The whole purpose behind this particular operation is to enable the company to procure raw materials and use them in the most profitable way. Prior to this particular analysis, the company would be as much as two months late in deciding whether or not to buy a particular set of raw materials. A particular solution to this problem on a large electronic computer (I.B.M.) involves a little more than 20 min. to produce a set of outputs for a given set of parameters.

PRODUCTION MANAGEMENT

The electronic computer may also be an aid to those involved in process production management. A typical problem involves the flow of materials in process with materials going through various branch points, for recycling or for combination into new products. In one such problem, an analysis of the chemical process indicated that the current practice of recycling a certain percentage of one of the intermediate outputs should be completely abandoned. With a fresh view of the whole flow process, particularly the decision points at which production management decided upon recycling or new product definition, inventories were reduced, waste was recovered, and for a given output yield the profit was increased. In addition to this, the production levels were geared more directly to the redistribution of sales with respect to time —the particular process involving one in which output materials are produced for inventory rather than order. The importance of such an application lies in the ability to state quantitatively the parallel cost and yield expressions by determining the yield at each particular stage in the process of each product. By a knowledge of costs and prices of these products, over-all cost equations could be written. On the basis of these cost equations, the determination could be made as to the value of recycling for various intermediate product definition. With such a mathematical model built of the material flow and the associated cost structure, a wide variety of operating procedures can be enumerated, displaying for production management those schedules which will assure optimum profit with smooth production.

Another example of the use of the electronic computer as an aid to production management occurs in metallurgical analysis. Several steel companies are using correlation methods to study the operation of open-hearth and blast-furnace operations. By the improvement of operating practices, considerable savings have occurred.

Of course, the essential aspect of using the computer as an adjunct in production management lies in its ability to handle simultaneously many decision variables and to enumerate the behavior of the total system once it has been described in a quantitative mathematical model. Under this mode of operation, the computer does not necessarily select the operating procedure but it certainly expands the scope of intuition on the part of production management.

AUTOMATION

Much interest has been generated in the possible use of the electronic computer as a component of control in the automatic factory.

The appearance of such articles in the chemical engineering journals indicates that the chemical engineer is becoming increasingly aware of the importance and possibility of automatic control. Indeed, the chemical engineer

has been responsible for the major efforts in process plant automation thus far. For example, in the August issue of C.E.P., a series of four articles was devoted to this general subject. Paul Wilks (*6*) points out that almost all existing instrumentation in processing plants is designed to control process stream *environment*, such things as temperature pressure, flow rate, etc. However, continuous analyzers, by measurement of stream composition, will be used to set automatically environment controllers. The next logical step in such an arrangement is to interpose a computer between the continuous analyzers and the control elements, to make the control decisions automatic, based upon predetermined instructions. Berger and Campbell (*2*) point out the fact that apparently most fractioning columns are designed with only steady-state conditions assumed. Such assumptions are idealizations and before true automatic control can take place consideration must be given to the time lags of proposed control loops. This will involve the extension of chemical engineering practice into a new field commonly referred to as systems engineering wherein the whole control phenomenon is viewed as an integral system.

In the use of the computer as an automatic control element, it is assumed that closed-loop control would be used. In this type of control, information is fed back from the output of the controlled system to the computer so that an adjustment can be made for the deviation between the observed output and the desired setting.

Before automation can take place within the chemical industry several new viewpoints will be required on the part of the chemical engineering manager. Automatic control implies a complete mathematical and logical description of the chemical process taking place. This will also imply a tremendous step forward in the theory of chemical operations. In this regard the remarks of Wayne Alexander and of J. F. Draffen, both affiliated with Monsanto, are worth reading. Alexander (*1*) said:

The science or art of chemical engineering has, after all, been based on empirical information. It is one thing to develop correlations in the design of a piece of equipment for benzene-toluene separation, but when you use something other than benzene the same unit doesn't seem to act the same. We find the whole area of chemical engineering susceptible to this variability. We find that the judgment of the process designers moves factors one way or the other, perhaps intuitively, to accommodate these changing environmental factors.

This indicates a great need for theoretical consideration in the design of equipment for the use in a particular chemical process.

Draffen (*3*) said:

It isn't so much the instruments that determine the control as it is the process, and to predict how the process will operate under automatic control, it is necessary to make not only ordinary heat and material balances, but also dynamic balances which essentially mean being able to write differential equations for the plant.

It is essential to realize that automatic control will imply control of a dynamic situation rather than one which operates as a steady-state phenomenon.

Ernest Johnson has described how frequency response can be used in chemical control (*4*). In essence, he wrote that

the ability to design automatic self-regulated chemical processes will require the chemical engineer to have a knowledge of the basic principles of servo-mechanism theory. As automatic control increases in complexity, more process variables may be controlled simultaneously. This will involve complicated analyses of the stability of systems. Similar stability analyses are currently being performed upon computers in various areas associated with defense activities.

Another aspect facing the chemical engineer of the future is the determination of the number of control stations needed to monitor a particular operation. It is doubtful that simply extending the present type of environmental control with the great number of instrument panels located in one spot would be either desirable or workable. It is here that the computer can play an important part. Perhaps the automatic plant of the future will have several small computers operating under the control of a large, master monitor computer which can correlate and control the effect of several smaller processing units. Such analysis will require a great deal of engineering, computer and systems skills, bringing all to bear upon the economics of each particular situation.

A final aspect of automation which must be considered by chemical engineering management is the effect of such automation upon the method of doing business. Certainly changes in production will become more expensive as the degree of automatic control is increased. Varying the levels of production in a highly automatically controlled operation will be an expensive and time-consuming operation. This will mean an adjustment of present inventory and production policies. Considerations of such a broad business nature must clearly be a part of the chemical engineer's thinking in designing for automatic plants.

I.B.M.
random access
memory device.

computers

Today, instrumentation is capable of performing millions of operations without error and is designed to limits of reliability far in excess of human abilities. It remains now for the chemical engineer to utilize the equipments which are available to him today and which will be available in the future in making the automatic factory a realization out of the dream.

By working together, the chemical engineer, computer expert, and instrumentation expert can undergo a process of mutual education which will guarantee not only better equipment but also greater productivity at less cost.

Literature Cited

1. Alexander, Wayne, *Chem. Eng. Progr.*, **51**, No. 8, 343 (1955).
2. Berger, D. E., and G. G. Campbell, *Chem. Eng. Progr.*, **51**, No. 8, 348 (1955).
3. Draffen, J. F., *Chem. Eng. Progr.*, **51**, No. 8, 343 (1955).
4. Johnson, E. F., *Chem. Eng. Progr.*, **51**, No. 8, 353 (1955).
5. Wiener, Norbert, "Cybernetics," John Wiley & Sons, Inc., New York, page 37 (1948).
6. Wilks, P. A., Jr., *Chem. Eng. Progr.*, **51**, No. 8, 357 (1955).

Presented at A.I.Ch.E. Lake Placid Meeting.

Du Pont's new Louviers Building, near Newark, Delaware, houses engineering activities, including design, construction, and engineering service. The last-named is a consulting service in all branches of engineering.

COMMENTS on C.E.P. Round Table on Equipment Performance and Maintenance History

J. S. Sayer | DuPont Company Wilmington, Delaware.

The recent round table on Equipment Performance and Maintenance History (Sept. C.E.P.) did not include a representative from the Du Pont Company, which firm has had considerable experience in these activities. Subsequently, Mr. Sayer of the Engineering Service Division, Engineering Department, Wilmington, agreed to prepare the following comments.—Editor.

It is interesting to read the account of an Equipment-Performance and Maintenance-History Conference of the caliber sponsored by Chemical Engineering Progress at Houston. The wealth of progressive views expressed there is reflected by many practices encountered in Du Pont plants. The maintenance and analysis of records within our company take as many forms as were reviewed at the Conference; these records depend of course on the needs and conditions of the particular operation. However, regardless of form, they all serve a common end—providing a factual economic basis for improvement in equipment, materials, or organizational practices that will lead to an improved product profit position.

Know-How in Building Records

We at Du Pont conduct manufacturing operations at some seventy-five locations under the direction of ten production departments. Operating practices among departments vary and no uniform maintenance-control system exists. However, our better equipment histories record both maintenance cost and equipment performance. Two general mechanical approaches are used to build these records, either of which may resort to I.B.M. systems.

One approach is based on work order preanalysis and application of standard time value. To assure complete job information, this system requires that any changes or unforeseen items that arise during the job are properly posted on the order. This provides good performance data, accurate material usage, and relatively good labor costs. The work orders are filed by equipment piece number and are analyzed from time to time by qualified engineers to summarize performance and cost information and to formulate recommendations.

The other approach is to record on a card or in a log book pertinent-cost and equipment-performance data each time a maintenance job is completed. Such records provide equally suitable information for careful analysis as those described for the first approach. Activity of the routine mechanic, which in some plants accounts for nearly 30% of total maintenance cost, must be incorporated in equipment records if they are to be complete. We have adopted the practice of having the work of these mechanics recorded on job tickets, which are filed by equipment piece number and incorporated into the history records.

The degree to which equipment-maintenance records are maintained and analyzed varies among plants. Although we rarely maintain records on such detailed items as valves in pipe lines, our practice is to maintain records individually on critical pieces of equipment when operating under unusual or stringent conditions, and to group duplicate noncritical equipment when units are exposed to same operating conditions.

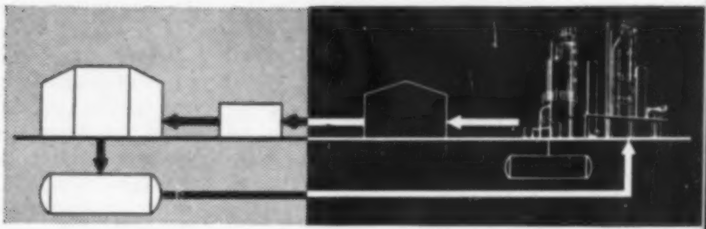
The value of maintenance records is increased substantially when they include the results of periodic inspections and other preventative maintenance practices. Such comprehensive records permit the determination of balanced recommendations for selecting equipment and materials and for improving standard job procedures and major equipment overhaul schedules.

Our general practice in analysis of equipment-history records is to extract annually all items for which the maintenance costs have exceeded a selected per cent of investment. Such cost data are supplemented by equipment performance and unscheduled outage information to formulate corrective action.

Certain exploratory work has been done by Du Pont in the application of statistical techniques to both equipment-history formulation and analysis. Thus, some interesting conditions have been uncovered enabling us on a few occasions, to predict accurately unscheduled shutdowns and equipment failures. Although few, these cases were in critical areas and they demonstrated that the application of statistical techniques in maintenance work deserves greater exploration than it has received.

Equipment-History Records Aid in Design

Another important use of equipment-history records is to provide the best possible information when a new plant is under design. It is rare these days that we design a new plant as a duplicate of an existing installation, and consequently, we advocate the keeping of rather precise equipment-history records during pilot plant and semiworks experience. This supplies our design organization with sound information on equipment performance for new designs. We also use the more routine history experience in our designs. In the design of new facilities the attempt is made to select the best economic material for the specific service, to install spare pieces of equipment only where it is economical to do so, and to provide a minimum number of units consistent with operating feasibility. All designs are reviewed during their preparation from the maintenance viewpoint to obtain maximum continuity of operation and to be certain of the inclusion of work areas and facilities that will contribute to good maintenance.



reactor fuel processing —
A NEW CHEMICAL BUSINESS?

B. V. Coplan and
J. K. Davidson

Knolls Atomic Power Laboratory, General Electric Company
Schenectady, New York.

As the engineer appraises the prospects of economic atomic power, he sees two areas where substantial improvements will have a direct effect in reducing the total mils per kilowatt hour. The first is in the design of the reactor where improvements reflecting decreased investment and operating costs will lower the power cost. The chemical engineer is directly concerned with development efforts in this area in such problems as heat transfer, coolant flow, and corrosion.

The second general area is the reactor fuel cycle. This is the particular place in which the chemical engineer can make a direct contribution to achieving economic nuclear power. Included in this area are the development and demonstration of long-exposure fuel elements, the development of inexpensive fuel-element fabrication methods, and the design of low-cost plants for the processing of spent reactor fuels. The economic possibilities in this field are the concern of this paper.

From steam drum to bus bar, the standard coal-fired power plant and the uranium fueled counterpart are similar. Only in the boiler end is there a major difference and here the coal-fired system will have the advantage of a lower investment. Of course, any improvement in the design of the reactor which reduces the investment or the operating cost is desirable. Undoubtedly, substantial improvements will occur. However, it seems likely that in the near future the reactor will require a greater investment because of its greater complexity and shielding requirements. If atomic power is to be competitive in the near future, the greater investment in a reactor must be compensated for by operating with a fuel-cycle cost lower than that of the coal-fired boiler.

Fuel-cycle Cost Explained

This simple economic fact is recognized in any evaluation of atomic power and in itself does not warrant further discussion. The interesting aspect lies in determining how to achieve a lower fuel-cycle cost. You will notice that the words "fuel-cycle cost" rather than fuel cost have been used here for the following reason: a fuel cost implies only the charge for new uranium periodically charged to the reactor whereas, the real comparison to the cost of buying coal, stoking the boiler, and removing the ashes is the atomic fuel-cycle cost. This latter figure is composed of three elements: the net fuel cost for consumed fissionable material, the use charges on the fissionable material inventory, and the processing cost which includes fuel-element fabrication and waste storage. By net fuel cost we mean the cost of new fissionable material less any credit received from sale of recovered fissionable material.

An appealing solution to the requirement for a minimum fuel-cycle cost is

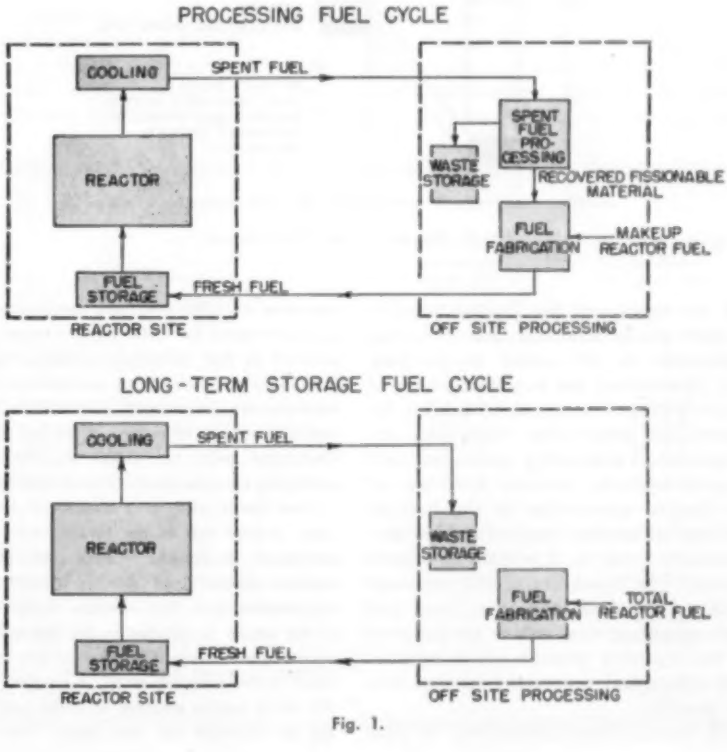


Fig. 1.

to develop a fuel element which can endure a long irradiation and then be stored indefinitely. From an accounting standpoint, this stored material is assumed to have no value, and hence the term "throwaway-fuel cycle" has been used to describe this type of operation. Actually, the fuel would be available for recovery at some future date if facilities for handling it became available. This eliminates current processing of radioactive material and decreases the total investment by not requiring a processing plant. This is a simple solution and is attractive to an infant industry which needs its capital to build reactors. Its feasibility depends upon the production at a reasonable cost of such a high burn-up fuel element.

The alternative solution is to process the spent fuel at a cost low enough to allow a credit to be taken for the unburned and newly formed fissionable material recovered. Conservation of natural resources and the limited supplies of high-grade uranium are powerful arguments for processing in the long run; in addition, the expanding uses of fission products may provide another incentive for processing. However, development of processing cycles demands support basically because it is one of the fruitful approaches to the over-all problem of making nuclear power economically sound in a private enterprise system. The feasibility of this approach is dependent upon the investment and upon operating costs which are incurred by the recovery process. It is believed that substantial reductions in this area are possible.

To discuss these alternatives of storing long burn-up fuel on the one hand, and processing on the other, the comparison has been simplified by choosing a typical reactor system as the basis for cost calculations. The two types of fuel cycle are illustrated in Figure 1. In this processing fuel cycle (top), chemical reprocessing of spent fuel is indicated. In long-term storage fuel cycle (bottom), only new fuel is fabricated and fed to the reactor; "cooled" spent fuel is hauled away to a long-term storage site for indefinite holding.

Since most of the present atomic power proposals consider a low-enrichment thermal reactor and since it is only for this type that storing fuel elements can be considered, we can use as a basis a heterogeneous thermal reactor rated at 1,000 mw. heat, 25% thermal efficiency, and a fuel of 1-2% fissionable material.

A fuel exposure of 10,000 mw./(day)/(ton) is assumed. This means that for a 100-ton reactor operating at 1,000 mw. heat, the average fuel exposure would be 1,000 days. Present developments in fuel technology indicate that this goal can be obtained. If appreciably longer exposure can be endured, the reprocessing of fuel becomes less attractive. If the fuel must be discharged prior to 10,000 mw./(day)/(ton), processing becomes relatively more attractive.

Since this is solely an evaluation of fuel-cycle costs, a total cost in the reactor area of 5.0 mils/kw.-hr. is assumed in each case. This cost includes reactor fixed charges, operating and maintenance costs. The inventory charge on fuel in the reactor is included in the fuel-cycle cost. As stated previously, it is expected that improvements in this area will occur. A constant cost of 5.0 mils is used to establish an initial goal which the net fuel-cycle cost must attain. Our target cost for power is assumed to be 7.5 mils/kw.-hr., thus a cost of 2.5 mils/kw.-hr. or less must be achieved for the reactor fuel cycle.

Single **heterogeneous low-enrichment reactor; 10,000 mw./day/ton fuel exposure 1,000 mw. heat rate; 25% thermal efficiency.**

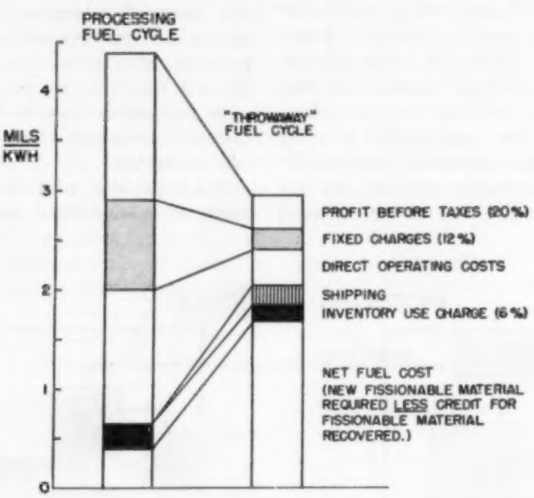


Fig. 2. Elements of the fuel-cycle cost.

An A.E.C.-sponsored Survey

Data for the discussion that follows was obtained from a study of spent fuel processing (*4*).

Figure 2 shows the elements of the fuel-cycle cost for a single reactor and an accompanying processing and fuel-fabrication plant. We are treating the fuel processing as a chemical business. It is assumed that the power company is not interested in entering the chemical business and, therefore, contracts to have its dirty fuel "dry cleaned" by the processing plant. The recovered plutonium is blended with fresh uranium of such an enrichment as required to maintain the reactivity characteristics of the reactor. This material is then fabricated and returned to the power company.

In our accounting procedure, we have assumed a 6% annual charge on the power company's nuclear material inventory in the reactor system. This includes the proposed A.E.C. "use charge" of 4% plus insurance and handling charges. For the chemical business we have used a profit before taxes of 20% of the processing plant investment, a depreciation rate of 10% and 2% of investment for the total of insurance and local taxes. This results in a "pay-out (after taxes)" of five years for the processing plant.

The costs shown in Figure 2 are calculated from the estimated investment and operating costs for a one-reactor processing plant based on design and operating concepts used at present by operating plants. It should be noted that the total fuel-cycle cost is about 4.4 mil/kw.-hr. Calculated on a comparable basis, the cost for simply storing the fuel after 10,000 mw./(day)/(ton) exposure is about 2.9 mil/kw.-hr. and the incentive for processing seems to be out the window. However, even the fuel storing costs about 0.4 mil/kw.-hr. more than the 2.5 mil/kw.-hr., which is our assumed tolerable cost.

Let us examine our fuel-cycle cost of 4.4 mils. For any given reactor design the fixed charges on the inventory and the net fuel costs are assumed to be fixed. Any improvement, therefore, must be directed at reducing the fixed charges and direct operating cost of the processing plant. This can be accomplished in two ways: one by processing several reactors in a single plant, gaining the benefits of larger scale operation, and reducing the unit cost; the other, of course, by simplifying the design of small-scale plants so that an appreciable reduction in investment and operating costs is achieved.

Figure 3 presents an analysis of these alternatives. The solid curve illustrates the estimated fuel-cycle cost as a function of capacity. It is based on carefully estimated fuel-cycle costs for three plants corresponding to a capacity for process-

ing one, five, and eighty reactors. These costs are estimated for plants using present-day design and operating philosophy and, as stated previously, are based on data obtained during the "Project Separation" study. The broken line represents throwaway fuel-cycle cost. This cost is also a function of capacity of the processing plant which in this case consists only of the fuel-fabrication plant.

This fuel-cycle cost vs. capacity curve demonstrates that processing the output of several reactors in a single plant will reduce appreciably the fuel-cycle cost. It will be noted that initially the cost decreases sharply with increasing capacity. It is also interesting to note that at a plant capacity equivalent to five reactors, the fuel-cycle-cost curves for processing and for throwaway cross at about 2.4 mils/kw.-hr. That is to say, that even with processing plants as they would be designed today, a chemical business exists if the fuel from five or more low-enrichment reactors is processed in one plant. One other characteristic of the curves is important, namely that beyond about ten reactors the benefits of increasing capacity are less marked. Increasing the plant capacity to eighty reactors decreases the fuel-cycle cost to 1.4 mils.

Has the goal been achieved so simply? All we have to do is build one processing plant–the larger the better–and atomic power is in competition! Or is there a catch?

A basic assumption is that we are envisioning a completely private industry. This means that present A.E.C. processing facilities will not be available for handling spent fuel from private power plants. This assumption is based on the need for weapons material continuing for an unforeseeable period, the isotopic and chemical difference in these fuels, and equally important, the reluctance of a large-scale private power industry to be dependent upon a government-operated facility for its very existence.

In an examination into the feasibility of constructing a private large-scale processing plant the following information supplies a good background.

The A.E.C. and private study groups (*2*) have estimated the growth of a nuclear power industry. All agree that in ten years only a small number of full-scale privately owned and operated power reactors will be on the line. In twenty years, it is estimated that about 10% of the total electrical generating capacity will be nuclear powered. This means about 40 million kw. of capability, or based on 1,000 mw. heat/reactor at 25% thermal efficiency, a total of about 160 reactors. However, the number of reactors added in any one year increases slowly from two or three in 1965, to perhaps ten in 1970, and to forty in 1975.

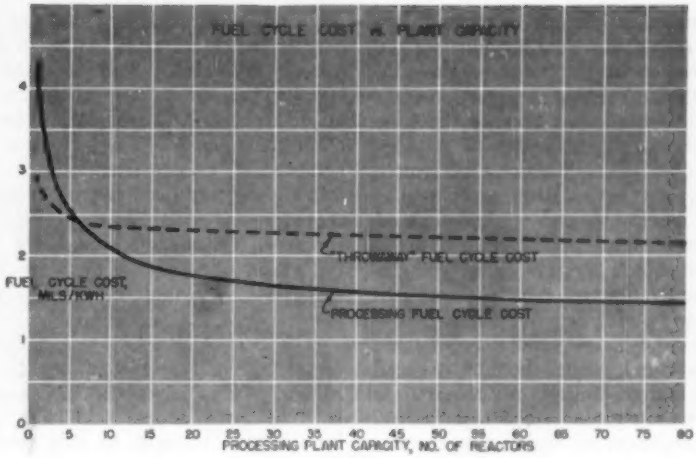


Fig. 3.

There is today a wide variety of reactor designs under consideration for use with an even wider variety of fuel elements. Important differences exist in the cladding material, in the physical shape and composition of the fuel, and perhaps most important, in the isotopic enrichment of the fissionable material. Undoubtedly, at least several types will be built and it will be at least ten years and probably longer before a single type can demonstrate economic superiority. It does not seem reasonable then to assume that in the next fifteen years a sufficient number of similar reactors will be built to enable the operation of a large-scale processing plant for one type of fuel; rather one to ten reactor capacity plants seem more probable.

If the prospect seems more favorable for smaller capacity plants in the foreseeable future, the "decreasing unit cost-with-increasing capacity" method of achieving low-unit cost is of limited help in reaching competitive fuel-cycle cost. Let us look, therefore, at the possibilities for reducing the fixed charges and operating costs of the smaller scale processing plants.

Present A.E.C.-sponsored irradiated fuel-processing plants, designed and constructed by competent architect-engineers and contractors, are expensive to construct and to operate. The operators are skilled by long experience and are as cost conscious as any group in the chemical industry in general. However, most, if not all, of these plants were constructed on a cash basis to meet military commitments. Meeting the scheduled start-up date was a most important

Table 1.—Comparison of Processing Plant Cost Factors

	Typical reactor processing plant (*5*)	Typical chemical industry plant (*1*)
	Factors based on installed process equipment = 1.0	
Installed process equipment	1.0	1.0
Installed piping and valves	0.8–1.4	0.4–0.6
Installed instrumentation	0.4–0.6	0.1–0.2
Building	1.0–1.6	0.6–1.0
Auxiliary facilities	1.5–2.0	0.3–1.0
Total physical cost	4.7–6.6	2.4–3.8
	Factors based on total physical cost = 1.0	
Total physical cost	1.0	1.0
Engineering and construction overhead	0.6–0.75	0.3–0.5
Contingency	.25	.25
Total capital investment	1.85–2.0	1.55–1.75
Total capital investment as a factor × installed process equipment	8.7–13.2	3.7–6.6

objective. Considerable effort was expended on process development, but the equivalent effort on design engineering to simplify and reduce construction costs could not be allowed because the time required was not available.

The operating philosophy of remote maintenance and installed spares used in several plants to prevent unscheduled shutdowns is inherently expensive. It requires exotic designs and includes such auxiliaries as remotely operated cranes and manipulators. It also greatly increases the cost of standard equipment and process piping because special flanges and mountings are required to enable remote removal and replacement. This investment for remote maintenance may be justified for large-scale plants since it becomes a small increment per unit cost of product and decreases repair time. It cannot be considered for the small capacity plants under discussion here. Other factors which contribute to the high costs include extensive and frequent sampling, "ever-safe" designs to overcome criticality problems, and waste disposal by retention in expensive tanks.

It is estimated that a plant processing radioactive material designed under these concepts costs about twice as much as a comparable standard chemical plant to build and several times as much to operate and maintain. Table 1 compares on an admittedly simplified basis costs which are considered to be representative of present-day reactor-processing plants with average chemical-industry costs for plants of the same general degree of process complexity. It will be noted that for equal process equipment cost the total investment in the radiation plant is more than *twice* as great. In the radiation process plant it is of even greater interest to note that even if the process equipment were obtained and installed free of charge, the cost would be reduced only about 10%; on the other hand, an equal reduction can be achieved if the construction and engineering overhead rate were reduced to the percentage common to the chemical industry. Of course, even more basic reductions can be made in the building, the piping, and most important, in the auxiliaries.

It is not claimed that this evaluation of present plants is new or novel; on the contrary, many chemical engineers in both design and operation have given considerable thought to this problem. Simplifications, particularly in building design, made to reduce investment and operating costs, have been proposed (*3*). However, it is not the purpose of this paper to discuss in detail how designs can be simplified—rather the objective is to indicate the most rewarding area for efforts to reduce the cost per kilowatt hour. The present separations processes are already highly efficient. As with reactor design, undoubtedly improvements resulting in cost reductions will occur. For specific reactors and fuel elements, special processes may be developed which are highly effective. In general, however, for the heterogeneous thermal reactors under discussion here, this does not seem likely in the near future. The "Project Separation" survey indicated little promise of major cost reductions through process improvement. In contrast, because of the large investment, annual fixed charges and profit before taxes account for more than 50% of the total processing cost. This is true despite conservative operating philosophy and procedures which make for high operating costs.

Hence, the more fertile area for development effort is not the process itself but the design of the plant and its auxiliaries. Basic to this development is the establishment of new philosophies of design and operation that recognize the relative magnitude of the various components of the cost. The focusing of development effort, both design and experimental, in these areas of major cost contribution will provide the best chance for significant reductions in the fuel-cycle cost.

The magnitude of the reward is shown in Figure 4. The cost vs. capacity curves of Figure 3 are the broken lines. The solid curves show the fuel-cycle costs if a reduction of 25% in plant investment and operating expense is achieved. One will note that the intersection between the processing and throwaway costs now occurs at about a capacity of three reactors, and that at a capacity of about five reactors a total fuel-cycle cost of 2.0 mil/kw.-hr. to the power company can be achieved. As before, the pay-out time for the processing company investment is five years.

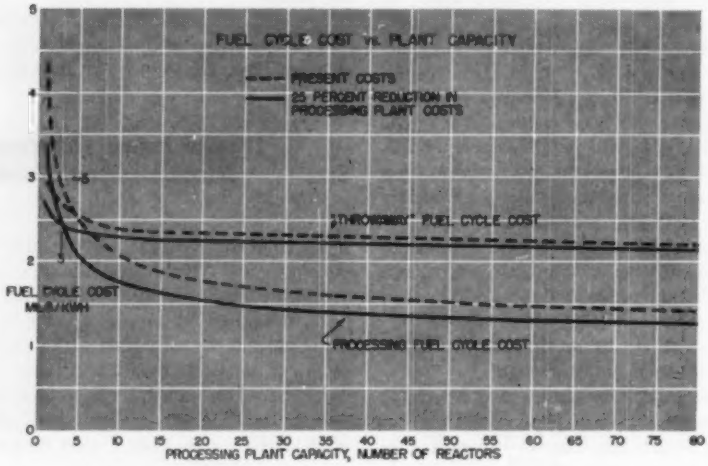


Fig. 4.

Engineering Talents Needed for Cost Reduction

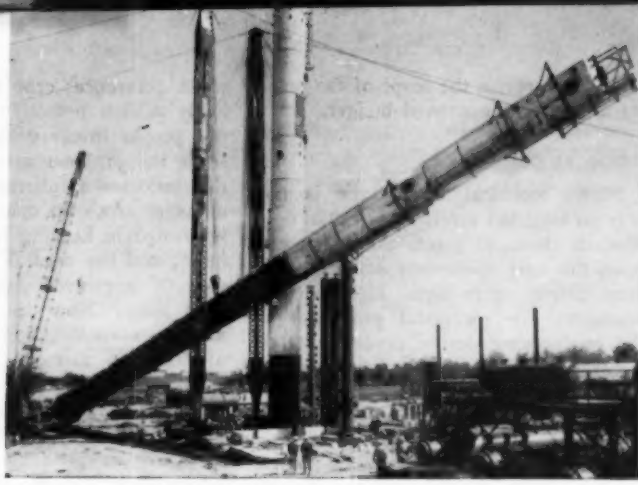
In conclusion it should be stated that, since discarding spent fuel will not in the long run be economic, it is recommended that engineering talent be directed to radical refinements in processing-plant design concepts and operating and maintenance procedures to reduce investment and operating costs. It is believed that such improvements can be accomplished without sacrifice to safety or process efficiency.

Since construction of a large-scale plant does not appear to be economically feasible for at least fifteen years, these improvements can be and should be applied to the design of smaller—three to ten reactor capacity–processing plants. Reductions in over-all fuel-cycle cost through efficient processing can play a major role in creating economic power from atomic energy, and at the same time, create a new chemical industry.

Literature Cited

1. Chilton, C. H., *Chem. Eng.* (June, 1949).
2. McCune, F. K., "The Race for Atomic Power." Address before Southeastern Electrical Exchange, Boca Raton, Florida (March 23, 1955).
3. Project "Hope," O.R.N.L.—1638.
4. "Project Separations." Processing of Spent Power Reactor Fuels. A.E.C. survey at M.I.T. (1954).
5. "Project Separations" and O.R.N.L.—1792.

Presented at A.I.Ch.E. Lake Placid meeting.



WHAT MAKES A project manager

Raymond F. Burghardt

Lederle Labs, Pearl River, New York

The great expansion of our modern industrial establishments has been accompanied by a sharp increase in the complexity of technical problems.

The design and construction of our process plants are now dependent upon much more than the skills of their design engineers. It is not enough to employ the best electrical, chemical, mechanical, or civil engineering know-how to lay out and develop the details of the new modern plant. Someone is needed to tie together these skills into a smoothly functioning organization. Thus a new kind of job, namely project managing, has become significant.

A New Kind of Job

In charge of this assignment is the project manager, the coordinator, the job manager, the one who applies *good judgment* and *economic common sense* to the multiplicity of data which flow from the design departments.

Looking briefly into some of the project manager's duties, one should note the following. First, he is management's top representative on the new project. In most organizations he is the man who gets in on the ground floor of a new product, prepares rough estimates on construction costs and perhaps on manufacturing costs for management review. It is his job to prepare budget estimates for financial approval. Subsequently he coordinates the activities of the many engineering services to prepare construction details on building and structural design, process equipment and machinery layout, electrical installation, utilities services, and the countless other details that make up the modern plant.

An important function of the project manager is to supply specifications and drawings to the purchasing agent for soliciting bids and to assist in recommending manufacturers, suppliers, and competent contractors. He will want to be sure that purchase orders and contracts are awarded to reputable people who can guarantee services in accordance with sound engineering practice, that all commitments are held within the tight confines of his budget, and that during the construction stages he must continuously satisfy himself that specifications and contracts are being properly observed.

Illustration courtesy Chemical Construction Corporation.

Throughout the duration of every project, two important items must be kept to the front: (1) the relation between job cost and budget authorization, and (2) progress schedule. All design and construction activities are tied in with these important points. The project manager cannot delegate responsibility for them to anybody else.

What One Should Be

What kind of person does it take to fit into this role? Without attempting to list the characteristic traits in order of importance, the following will indicate some qualities that make a successful project manager.

1. management-thinking orientation
2. mature judgment
3. cost-consciousness
4. technical competence
5. leadership ability
6. determination, aggressiveness, perseverance
7. alertness

ATTITUDES

As management's right-hand man, the project manager is expected to be fully cognizant of his company's hopes for the project. He is the man who has been in on the job from the beginning, has probably attended policy-making meetings and rough-and-ready sessions when the pros and cons of the project were hammered over the conference table. All of this has conditioned him to a sympathetic mutual understanding with his top bosses. The important points here are that this conditioning causes him to think like management and brings into play an inspired loyalty with every decision which he may be called upon to make. The man who is so minded will pass on to his subordinates an enthusiasm which engenders loyalty throughout the organization.

MATURITY

The expression "Sending a boy to do a man's job," can not be applicable here and should not be. There can be no doubt that successfully engineering a new modern process plant is a man's job. And yet how many times we see a "boy" struggling through this man's job, completely handicapped by an inability to assimilate the accumulation of information, data, personal opinions, and even hearsay, to separate the sense from the nonsense, to draw a reasonable conclusion, and then to act upon it.

Mature judgment certainly comes and develops with experience. It feeds upon our as well as others' mistakes and successes. It cannot be measured in years and is frequently unrelated to age. This quality is rarely formed in school but rather is it created through the constant application of those thought processes by which, in the engineer's case, he is continuously relating one problem to another, studying the effects of one idea upon all related factors. Some maintain that a certain amount of intuition seems to be an important aid in the application of judgment but, if properly analyzed, it will be evident that our so-called intuition is simply a spontaneous assembly of ideas drawn from our experience. As we grow rich in experience, so, also, do we develop intuitive powers.

The writer believes that the project manager must be generally conservative in his nature. He must be patient if

he is to draw the fullest cooperation from the many types of people upon whom he is dependent—engineers, purchasing agents, accountants, construction people, contractors, and union bosses. He must weigh carefully but quickly the merits of design and construction changes. Nothing can so thoroughly wreck the project manager's two prime objectives—schedule and cost—as to permit indiscriminate alterations in design and construction. The greatest pressure will be brought to bear upon the project manager by everyone from top management to the janitor to incorporate their pet ideas into the project. Admittedly, some of these will be difficult to resist. Some may be fundamentally sound (but better left until after the job is completed), others may be necessary, and a few may be politically inspired by top management. In any case, no change, however small, should ever be accepted without making a careful review of its effect upon the cost and schedule, followed by a prompt report to management of any revisions in either that may be incurred. Generally speaking, it is my opinion that few design changes can ever justifiably delay a project after it has gone into the bidding stage or into construction.

COST-CONSCIOUSNESS

I don't know whether cost-consciousness is something that grows on us or is inherent in our nature. Some engineers seem to possess a sense of values in the early stages of their careers. Others never acquire it. It just is not conceivable that a project manager can conscientiously represent his company unless he understands thoroughly the value of a dollar and knows what it should buy in terms of material and labor.

One of the basic requirements of the project manager will be an ability to set up a simple but thorough system of accounts staffed by competent personnel to maintain a day-by-day record of job expenses and a continuous check against budgeted items. These records will furnish an up-to-date accounting at any time of his job's financial status and will serve as the basis for periodic reports to management.

No project manager can ever be excused for knowingly or unknowingly permitting a job to overrun. With a proper system of cost accounting and due diligence thereto, he should receive ample warning of any danger spots long before they develop. A red flag waving from the balance sheet should be a sign for quick action, first to study the problem carefully and then, if necessary, to advise management promptly so that the proper authorities may decide whether to continue with an additional appropriation or revise the scope of the project to meet the approved budget.

TECHNICAL COMPETENCE

Sound technical competence is not only an asset but surely an essential one. Modern chemical plants are a far cry from the unit operations of twenty or even fifteen years ago. Most project managers are successful graduates of the engineering design departments of American Industry. They have been on the board, pushed slide rules, made estimates, written specifications. They know the inside problems of design. Nevertheless, a project manager does not necessarily have to be a top-notch designer.

OTHER QUALITIES

Many other characteristics are of greater or equal importance such as leadership ability. Everything that has been said about the project manager points up the all-important need for a man who can manage and direct, a man who can inspire the confidence of management, of his co-workers, and of his staff and assistants. Much has been written about the qualities of leadership. Suffice it to say then that the principal function of the project manager is to lead, to inspire an enthusiastic desire among all his associates to cooperate to the fullest, to pave the way for a smooth cooperative venture from which each man will derive that satisfied feeling of a job well done.

WHEN THINGS GO WRONG

It has been the writer's observation that the speed or progress of a job is in direct proportion to the amount of effort which the project manager puts into it. No single factor can contribute so effectively to the dragging out of a job as an indecisive project manager. The experienced man has learned many techniques which, when properly applied, can materially speed up construction and, thereby, hasten the day when pay-off time can begin. An alert manager will anticipate bottlenecks and avert delays before they have an opportunity to occur. He can sense the attitude of his staff and of the construction worker and he can be prepared for those countless annoying problems which are an inherent part of every job. He may frequently be called upon to reconcile differences between contractor and labor, if only to assure an uninterrupted job schedule. Most grievances invariably call for a sensible compromise, getting each of the parties to give and take a little as a temporary solution until time can be provided for a more permanent settlement.

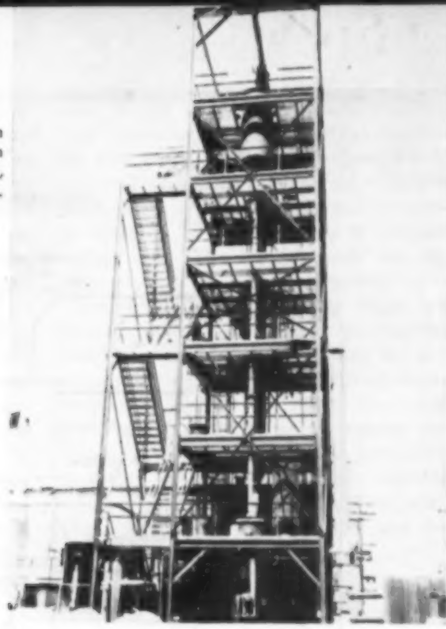
The important thing to remember when differences crop up which appear likely to interrupt job progress is to get the people involved face to face and settle the problem at once. Invariably this becomes a function of the project manager since no one is ever quite so interested in keeping a job moving as he is, and the natural tendency on the part of aggrieved parties is to avoid each other. Now this requires a rare ability or combination of abilities, the alertness to foresee the problem, the aggressiveness to tackle it without delay, the leadership to bring the parties together, and the maturity of judgment to arrive at a workable solution with which all will agree. Perhaps an agreement can't be reached. In that case the project manager may have to take the responsibility of making his own decision and then making it stick.

TRAINING

As the scope and magnitude of engineering projects grow with the complexities of modern civilization, the role of the project manager has become increasingly important. The ranks are currently being filled mostly from the chemical and mechanical engineers and from others who show the most promise of graduating from the design engineering arena to positions of management responsibility. Perhaps this is adequate to meet current needs. For the long run something further is required to provide the stimulus to get engineers to think along project lines. A prescribed course of study on the graduate level could be in order. Such a course would cover the basic principles of organization, budgeting, cost accounting, contracts, labor law, and industrial relations.

One also senses that many of our good design engineers who would be excellent prospects for project management positions are not taking full advantage of their potentialities but instead are concentrating their efforts and training too heavily in the specific engineering profession of their choice. This is particularly true of the younger, new college graduates. I can sympathize with the desire to apply the chemical engineering knowledge with which they are bursting, but they should be shown that promotions are not usually dictated by technical skills alone but rather by those abstract qualities known as versatility, dependability, compatibility, and initiative.

It would seem then that the lesson to be drawn is this. Diversification of interests supplemented by a versatile education in the early years is of the utmost importance if the engineer is to provide the maximum use of his abilities throughout his career, and if industry is to be assured of a steady supply of competent project managers.



View of the ammonium sulfate decomposition unit at Mulberry, Florida.

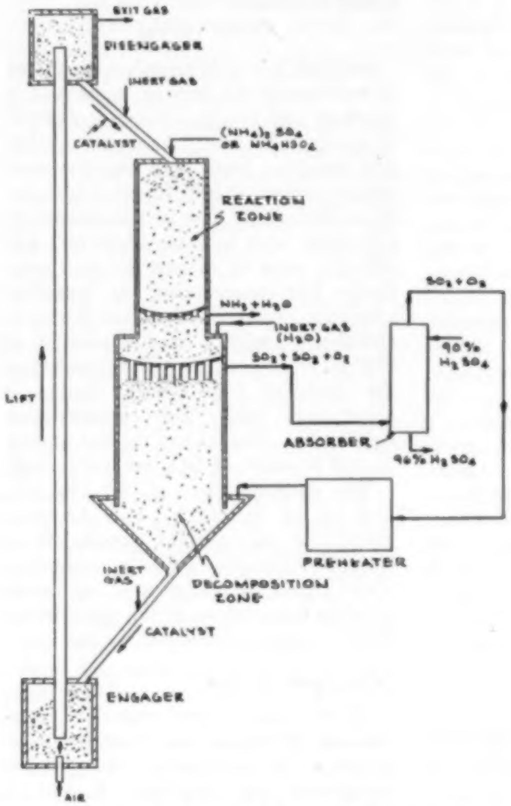


Fig. 1. Ammonium sulfate decomposition process.

PILOT PLANT FOR decomposing ammonium sulfate uses moving bed

J. W. Delaplaine — Catalytic Construction Company, Philadelphia, Pennsylvania

Robert F. McCullough — International Minerals & Chemical Corporation, Skokie, Illinois

A continuous moving-bed pilot plant for the decomposition of ammonium sulfate into separate gaseous products of ammonia and sulfur oxides was operated by International Minerals and Chemical Corporation, Mulberry, Florida. The process employed may permit production of sulfuric acid at a price competitive with contact or chamber acid in some areas. Discussed here are: (1) a new chemical process of potential economic importance, (2) the design and operation of a relatively high temperature moving-bed unit with the problems encountered, and (3) some unique applications of a moving-bed technique.

International Minerals and Chemical Corporation investigated a project which produced large quantities of ammonium sulfate. Since this quantity of by-product ammonium sulfate could not be marketed, a new process was developed to permit cyclic uses of both ammonia and sulfur oxide gases. The process required removal of the gases in separate heating zones.

Satisfactory operation also would permit production of sulfuric acid from gypsum in times of bad sulfur economics, since ammonium sulfate can be made quite easily from calcium sulfate by reaction with ammonia and carbon dioxide.

Following extensive laboratory studies, a pilot-plant employing the moving-bed technique was designed, constructed, and operated.

The moving-bed technique, as defined by Happel (*1*), is one in which relatively large diameter granular solids move downward by gravity, remaining in contact with each other and thus in essentially the same relative position to each other. Fluids can be made to flow concurrent or countercurrent to the solids to effect chemical or physical changes, and the desired temperature gradients can be impressed across the various zones of the process by a multiplicity of methods. Perhaps, the best know applications of the moving bed principle are the TCC and Houdriflow catalytic cracking processes, Hypersorbers, and pebble heaters.

In the ammonium sulfate decomposition process, inert particles impregnated with ZnO are brought together with ammonium sulfate in a reaction zone, where SO^3 combines with ZnO to form zinc sulfate, releasing ammonia gas and water vapor. The ammonia and water pass out of the reaction zone as vapors, while the inert solids, now impregnated with zinc sulfate, are heated and decomposed in the lower zone to regenerate the ZnO. Oxides of sulfur are released. The regenerated solids are then elevated to the top of the unit by an air lift where they are ready to start the cycle over again by flowing into the initial reaction zone.

The research division of International Minerals and Chemical Corporation, Mulberry, Florida, developed initial process conditions using batch equipment. A 10-in.-diam. continuous pilot plant was designed by Catalytic Construction Company and operated at the same location. A satisfactory reaction mass, alundum spheres impregnated with ZnO, was developed and made at the catalyst manufacturing plant of the Houdry Process Corporation at Paulsboro, New Jersey.

J. W. Delaplaine is at present associated with Cox & Weinrich, Washington, D. C.

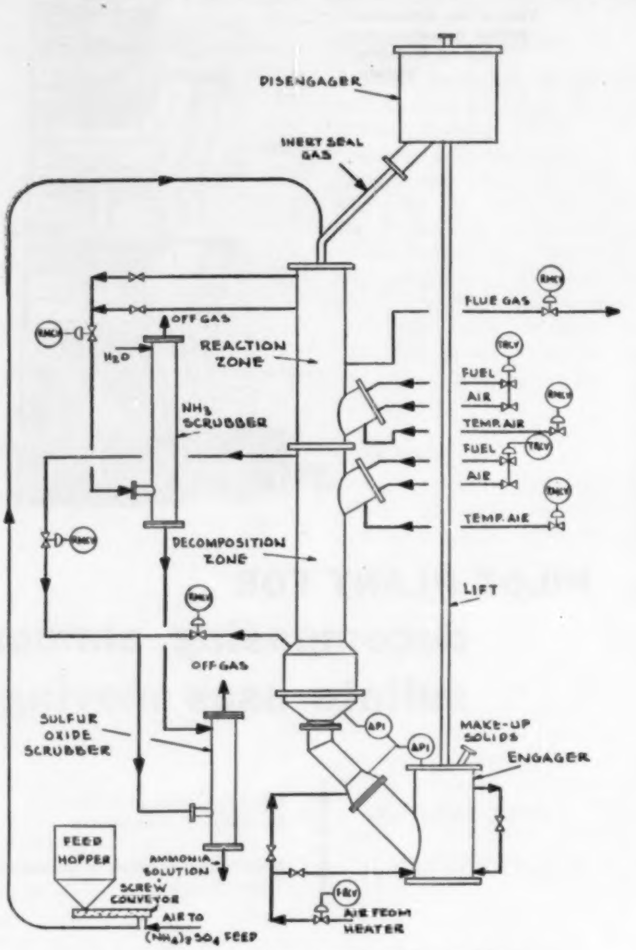


Fig. 2. Ammonium sulfate decomposition pilot plant.

PROCESS CHEMISTRY

If ammonium sulfate is thermally decomposed in the presence of an acceptor for sulfur trioxide, ammonia can be produced that is free of the oxides of sulfur and is recoverable by conventional methods. The acceptor together with the SO^3, which reacted with it, can be heated in a separate zone to regenerate the acceptor with the evolution of sulfur oxides. This gas can be converted catalytically to sulfur trioxide and absorbed in sulfuric acid to produce strong acid.

For the following reasons, zinc oxide was chosen from the class of metal oxides as the acceptor.

1. Zinc oxide reacts rapidly with ammonium sulfate to form zinc sulfate, ammonia, and water at a temperature above 400° C.
2. Zinc sulfate produced by the initial reaction starts to decompose at a temperature above 700° C. The temperature difference between starting of $ZnSO_4$ decomposition and completion of the ammonia volatilization is, therefore, sufficiently large to allow for flexible operation.
3. Zinc sulfate completely decomposes at a practicable rate below 1,000° C.

Reactions: The principal over-all reactions in the ammonium sulfate decomposition process are:

1. $(NH_4)_2SO_4 + ZnO \xrightarrow{500^\circ\,C.} ZnSO_4 + 2NH_3 + H_2O$

2. $ZnSO_4 \xrightarrow{850-1000^\circ\,C.} ZnO + SO_3$

Other reactions of interest are:

3. $NH_4HSO_4 + ZnO \xrightarrow{500^\circ\,C.} ZnSO_4 + NH_3 + H_2O$

4. $(NH_4)_2SO_4 \xrightarrow{250^\circ\,C.} NH_4HSO_4 + NH_3$

5. $SO_3 \xrightarrow{850-1000^\circ\,C.} SO_2 + \tfrac{1}{2}O_2$

6. $ZnO + 2ZnSO_4 \rightarrow ZnO \cdot 2ZnSO_4$ $(3ZnO \cdot 2SO_3)$

Reaction 1 is endothermic with a heat of reaction of 45 kcal./g. mole and a standard free energy change at 500° C. of about −26 kcal. Ammonia oxidation reactions have high negative free energy changes at 500° C., but these rates of oxidation are slow in the absence of a catalyst, such as iron. However, Reaction 1 must be carried out at a relatively low temperature to minimize ammonia oxidation. Reaction 2 also is endothermic with a heat of reaction at 850° C. of 53 kcal. At this temperature, the standard free energy change is about +11 kcal. The corresponding equilibrium constant and the equilibrium partial pressure of SO_3 are very small.

The decomposition of SO_3 to SO_2 and O_2 is favored by high temperatures. In the present process it is desired to minimize the SO_2 production. This is done by operating at the lowest possible temperature at the point where SO_3 is removed from the system.

LABORATORY STUDIES

Work was carried out by International Minerals and Chemical Corporation to determine the process conditions for reactions 1 and 2. The experiments consisted of heating in furnaces $(NH_4)_2SO_4$, NH_4HSO_4, ZnO, $ZnSO_4$, and mixtures of these materials to determine: (1) time-temperature-percentage decomposition relationships by weighing and analyzing portions of the sample, (2) continuous weight vs. time curves with a Chevenard thermobalance apparatus, and (3) instantaneous heat effects of the sample by comparison with an inert standard sample at the same constant heating rate (furnace heating rate of about 12°C./min.) using differential thermal analysis (DTA) equipment.

When ammonium sulfate is heated at temperatures under about 350° C., decomposition to ammonia and ammonia bisulfate occurs. At this temperature the reaction is about 85% complete, and a liquid melt of ammonium sulfate and ammonium bisulfate results. Finally, at higher temperatures, the bisulfate decomposes. All these reactions are endothermic. $(NH_4)_2SO_4$ loses 50% of its ammonia below 300°C., and 100% below 500°C. Furnace tests indicated that the reaction was complete in less than 10 min. at 450°C. This was confirmed by thermobalance data.

When a slight excess (10%) of ZnO was heated with $(NH_4)_2SO_4$, the DTA data showed an exothermic peak at

about 390°C. This suggests that SO_3 reacts first with a large excess of ZnO to produce $ZnO \cdot 2ZnSO_4$ and not $ZnSO_4$. On further heating, SO_3 combines with basic zinc sulfate to produce zinc sulfate. In all other repects the heating curve for the $(NH_4)_2SO_4$–ZnO mixture was similar to the curve for pure $(NH_4)_2SO_4$ below 500°C.

Differential thermal analysis data showed that $ZnSO_4$ is stable below 700°C. and undergoes an endothermic reaction ending at about 760° C. with the evolution of approximately one third of the sulfur oxides. This suggests that $ZnSO_4$ can decompose to $ZnO \cdot 2ZnSO_4$ in the temperature range from 700 to 760°C. A second endothermic reaction started slowly at 850°C. and ended at 970°C. with the evolution of the remainder of the SO_3. When $(NH_4)_2SO_4$ was heated with a 200% excess of ZnO, no exothermic reaction at 390°C, and no endothermic reaction from 700 to 760°C. were noted, suggesting, again, that only basic zinc sulfate is produced by reacting SO_3 with a large excess of ZnO. Actually, no economic advantage can be gained by operating with a large excess of ZnO. Furnace experiments indicated a contact time for complete $ZnSO_4$ decomposition of 10 to 15 min. at 1,000°C.

Similar studies showed that: (1) iron, copper, and aluminum oxides were not satisfactory because the sulfates were partially decomposed at temperatures below those required for complete ammonia recovery, and (2) calcium and other similar oxides required too high a temperature for practicable sulfate decomposition.

MOVING-BED CONSIDERATIONS

The ammonium sulfate decomposition process employs the moving-bed principle to transport zinc oxide between the reaction zones. The investment and operating costs of a commercial moving-bed unit were estimated to be lower than the costs of comparable mechanical hearths. The moving-bed method was chosen because it appeared to offer certain advantages over fluidized or fixed-bed operations. Countercurrent flow of gas and solids simplifies the SO_3 removal problem, and the moving-bed technique makes it relatively easy to seal between reaction zones and to introduce hot flue gas between these zones without necessarily contaminating the ammonia. The entire process can be carried out in a single vessel.

REACTION-MASS STUDIES

To obtain a reaction mass that would not mechanically disintegrate in either of the reaction zones, or agglomerate and lose its activity, zinc oxide was impregnated on an inert carrier. The use of a gas lift for circulating the solids required particles that would not undergo appreciable attrition. To reduce the heat requirements of the lower, or $ZnSO_4$, decomposition zone to a minimum, it was desirable to circulate a small amount of solids with a high ZnO content. This requires a reaction mass with a large number of active centers whose activity does not decrease appreciably with time under reaction conditions. In addition, the solids should be resistant to thermal shock. High-porosity, ¼-in. alundum spheres impregnated with $ZnSO_4$ and heated to produce ZnO met the process requirements. $ZnSO_4$ was impregnated on alundum and decomposed to ZnO in a moving-bed unit by flowing the catalyst countercurrently to a stream of air heated externally to a temperature of about 800°C. Essentially complete decomposition of $ZnSO_4$ was obtained at this temperature, and large amounts of sulfur trioxide were evolved. Thus, it was indicated that the countercurrent moving-bed operation reduced the temperature required for complete decomposition by about 150°C.

DESCRIPTION OF PROCESS

Because of improvements resulting from the investigations, the process differs slightly from the one studied in the pilot plant. The commercial process will be presented first, followed by a discussion of the system actually investigated. The moving-bed unit can be fed with either $(NH_4)_2SO_4$ or NH_4HSO_4, and certain advantages may result from the use of the latter feed. Thus, $(NH_4)_2SO_4$ can be heated and decomposed in an external zone at 250° C. with gaseous ammonia product from the moving-bed operation, which would then be fed with liquid bisulfate or sulfate–bisulfate mixture. This reduces the total heat load on the unit as well as the amount of ammonia in contact with oxidizing agents at high temperatures. However, this paper will be limited to a discussion of $(NH_4)_2SO_4$ feed.

PROPOSED COMMERCIAL PROCESS

This process is shown in Figure 1. The reaction mass, containing ZnO, flows by gravity into the top reaction zone together with powdered $(NH_4)_2SO_4$, which is transported pneumatically into the unit. Reaction 1 occurs as the solids and gas flow concurrently through the bed, and ammonia and water are removed as the gaseous product and sent to conventional ammonia-recovery facilities. The solids, now containing $ZnSO_4$, enter the decomposition zone where they move countercurrently to a stream of hot gas. This gas provides the heat to decompose $ZnSO_4$ (reaction 2) with the consequent evolution of SO_3. The product gas from this decomposition zone is absorbed in sulfuric acid to produce strong acid. The off-gas from this absorption step is heated externally in a conventional furnace or pebble heater and recycled to the bottom of the moving-bed unit. Inert gas is added between the two zones to prevent mixing of the product gas streams, as well as to seal legs above and below the reaction zones to prevent ammonia or sulfur oxide losses. The solids pass into an engager and are elevated with a gas lift to the gas-solids disengager. The solids flow to the reactor, and the cycle is repeated.

PILOT-PLANT PROCESS

The process studied in the pilot plant is shown in Figure 2. The equipment was designed on the basis of the laboratory studies, which indicated a temperature requirement of about 1,000° C. in the $ZnSO_4$ decomposition zone. All metal internals were eliminated because of the high temperature.

$(NH_4)_2SO_4$ was transported pneumatically into the top of the reactor where it

reacted with the zinc oxide. Ammonia was removed at the top of the bed or at a point about 6 ft. below and sent to a water scrubber. The heat for reaction 1 was supplied by the reaction mass which entered the bed at a temperature of 550 to 600° C. It was rapidly reduced, and the solids left the zone at about 450° C. Hot flue gas from the upper burner was used to preheat the solids leaving this zone to a temperature of about 650° C. This is below the temperature at which SO_3 is evolved from $ZnSO_4$. Most of the flue gas flowed countercurrently to the solids and left the reactor at a point about 2 ft. above the flue-gas entrance. A small amount was allowed to flow upward into the reaction zone to sweep residual ammonia from the bed and to prevent ammonia loss. An additional amount of flue gas flowed downward from the burner and out of the top SO_3 drawoff to prevent the loss of SO_3 in the top flue-gas take-off.

Additional hot flue gas from the lower burner entered the decomposition zone to supply the heat requirements for the sulfate decomposition step. This zone was designed with two gas take-offs for either concurrent or countercurrent operation. Later discussion will show that countercurrent flow did not permit complete removal of

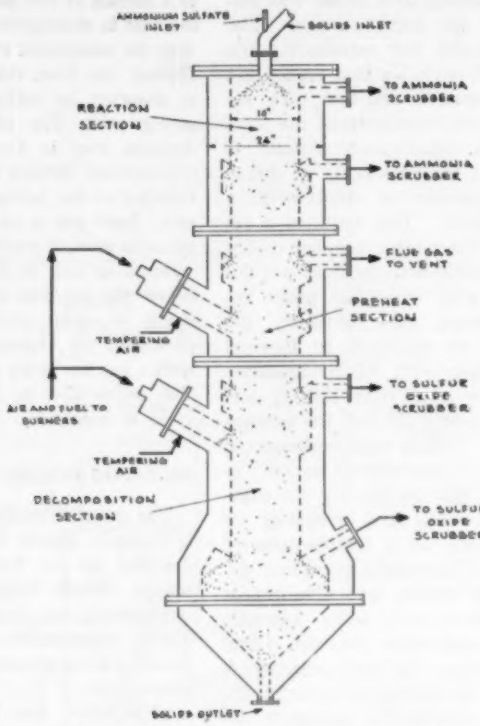


Fig. 3. Reactor design.

the sulfur oxides. Therefore, the upper drawoff was used in subsequent operations. Air from the engager flowed upward into the zone countercurrently to the solids to sweep the sulfur oxides from the bed. The gases flowed from the take-off to a scrubber where they were absorbed in the solution from the ammonia scrubber. The solids flowed by gravity from the reactor at a temperature of about 850° C. into the engager and were lifted by air to the disengager. They then flowed through an air seal into the reactor to repeat the cycle.

DESCRIPTION OF PILOT PLANT

A pilot plant designed to process approximately 100 lb./hr. of ammonium sulfate was erected. The unit consisted of (1) a 10-in. I.D. reactor, 30 ft. high, (2) a 2-in. diam. air lift, 55 ft. high, (3) an engager, (4) a disengager, and (5) auxiliary equipment such as reaction mass and $(NH_4)_2SO_4$ feeding systems, air- and fuel-supply systems, product scrubbers, and the necessary instrumentation, piping, and structural work.

Figure 3 shows the details of the reactor. Carbon-steel pipe, 24 in. in diam., was lined with 2½ in. of insulation and 4½ in. of silica-alumina refractory. The refractory was cut away, as shown in Figure 3, to provide annular zones for distribution of gases entering or leaving the bed. Propane burners were mounted on refractory-lined, 16-in. pipes, which were welded at 45° angles to the reactor shell, and tempering air was added to the short combustion chamber below the burners to reduce the temperature of the flue gas entering the bed.

Ammonium sulfate was introduced at the top of the bed into the catalyst inlet pipe. The solids flowed over an inverted cone within the bed to distribute the ammonium sulfate and the reaction mass uniformly over the cross section of the bed. The solids flowed out of the reactor through a refractory-lined seal leg and into the disengager. Alternate inlets were provided to introduce air into the seal leg or into the jet below the lift. Thermal shock was not a problem, and the jet inlet was used in most of the work.

Figure 4 shows the design of the refractory-lined engager. Solids flowed down the inclined seal leg into the engager. The jet of air imparted momentum to the solids particles and lifted them to the disengager (Figure 5). The solids particles flowed out of the lift and dropped to the bottom of the disengager. They then entered the reactor through a carbon-steel seal leg.

Solid ammonium sulfate particles were fed into an air stream by a Syntron vibrator or a screw conveyer. Fresh reaction-mass make-up was added from a pressurized hopper or at the upper end of the top seal leg. The remaining equipment was conventional.

PILOT PLANT OPERATION

In the initial operation of the pilot plant a number of mechanical and operating problems were encountered. These will be considered first, together with their solutions. Then the operation of the pilot plant will be discussed.

MECHANICAL PROBLEMS

Mechanical difficulties were encountered in the operation of the blower, the solids feeding apparatus, the burners, and the expansion joints. The blower was replaced with one that would produce the desired quantity of air at the design pressure of 10 lb./sq. in. The pneumatic solids feeding problem resulted from the hygroscopic nature of ammonium sulfate, which caused the solids to bridge wherever the cross section of the flowing solids was small. The Syntron vibrator was replaced by a 2-in. screw conveyer, which was more satisfactory. The burner control difficulties resulted from failures of the diaphragm control valves, the automatic ignitions, and the flame-failure cutoff controls. Stainless-steel expansion joints, located around the lift pipe at the bottom of the disengager and at the top of the inclined upper seal leg, warped shortly after they were placed in operation. Expansion joints were discarded and successfully replaced with solid plates having holes approximately ¼ in. larger in diameter than the lift or seal-leg pipes. Solids above the openings prevented the flow of appreciable amounts of gas into the atmosphere.

OPERATING PROBLEMS

Initial operating problems encountered in the pilot plant were soon recognized and attributed to difficulties in: (1) maintaining uniform solids circulation rates, (2) attaining the desired temperatures, (3) fusing the reaction mass with the refractory during periods of local overheating, (4) disengaging gases from solids, (5) eroding the refractory linings, and (6) obtaining and/or measuring ammonia and sulfur oxide recoveries. The problems resulted, in general, from the selection of a relatively soft, low-melting refractory and a design of the unit for too small a particle size (⅛ in.) with too large a zinc oxide content. The latter caused an appreciable increase in the amount of the gas required to heat the bed.

Solids circulation problems were solved by the addition of (1) a small cone at the bottom of the lift that was tapered outward to increase the tube diameter to particle-diameter ratio, and

(2) subway grating to collect fused solids. A small direct-fired gas heat exchanger was added to preheat the lift air to 700°C. This increased the bed temperatures in the upper reaction zone and produced the desired temperature of about 850°C. in the bottom zone.

As long as the solids circulated at a constant rate, local overheating could be controlled. However, if the solids flow was stopped while the burners were on, about 200,000 B.t.u./hr. of heat contacted the reaction mass adjacent to each burner, the temperatures of the particles and refractory rapidly approached that of the entering flue gas, and the solids and refractory fused and plugged the unit. This difficulty would probably have been avoided by using a high-melting alumina refractory rather than silica alumina. Fusion was reduced by shutting off the burners immediately after the solids flow had stopped.

Gas disengaging from the internal annular zones of the reactor was a problem because the flow of this gas was 100 to 200% higher than the design rate. Stainless-steel screens were placed over the annular openings or the take-off pipes to prevent solids entrainment. Plugging of the screens did not occur. Refractory erosion was reduced by installing metal liners in the disengager and in the low-temperature, or upper, zone of the reactor. Refractory erosion also would have been eliminated by use of a hard alumina refractory. Poor recovery of the sulfur oxides was obtained in the runs where concurrent flow in the lower zone was utilized. Zinc sulfate was not decomposed completely. SO_3 was evolved in the engager on contact with hot lift air. Countercurrent operation in the bottom zone eliminated this problem. The scrubbers were too small to handle the product gas streams because of their excessive amounts, and additional recovery facilities were utilized.

PILOT-PLANT OPERATIONS

Pilot-plant operation was satisfactory when the mechanical equipment and recovery facilities were in use. The desired temperatures and pressures could be maintained so that ammonia, essentially free of sulfur oxides, and sulfur oxides free of ammonia could be produced. Although the material balances were not as accurate as desired, they did indicate approximately 90% ammonia recovery, which was the minimum design criterion. It was concluded that sulfur oxide recovery was good. The concentration of SO_3 in this product stream was estimated to be about 50%, but exact analyses were not made.

Effects of the operating variables were studied. The primary control of the temperatures in the upper, or $(NH_4)_2SO_4$, decomposition zone was the solids circulation rate. No substantial amount of ammonia was lost at inlet temperatures from 500 to 600°C. The primary control on the lower zone was the burner output. Complete removal of SO_3 was obtained at a temperature of 850°C. It was possible to absorb up to 400,000 B.t.u./hr. of heat in the moving bed of solids without overheating the reaction mass and destroying its activity. The temperature profiles showed this heat absorption to occur within 2 ft. of the flue-gas entrance points. Recoveries of ammonia and sulfur oxides appeared to be independent of the $(NH_4)_2SO_4$ and solids circulation rates over ranges studied (i. e., excess ZnO concentration and solids contact time). Reaction-mass attrition and deactivation, and equipment corrosion did not appear to be problems in this process.

Continuous runs up to approximately 1 week in duration were made, and the general feasibility of the process was demonstrated. Experimental work on the over-all project under investigation by International Minerals and Chemical Corporation was discontinued, at least temporarily, and, therefore, pilot-plant work on ammonium sulfate decomposition was stopped before final improvements were completed and before much longer operating periods could be attempted.

Summary

Pilot-plant work showed that the moving-bed ammonium sulfate decomposition process was practicable, and process conditions were established. It was established that countercurrent flow of solids and a sweep gas lowered the temperature for $ZnSO_4$ decomposition by about 100 to 150° C., and, that true countercurrent operation permitted a reaction with a high positive free energy change to go to completion. In addition, it was demonstrated that in a moving-bed unit a large amount of heat could be introduced into a very small volume of solids.

Acknowledgment

The authors wish to acknowledge the contributions of T. H. Milliken, Jr., of the Houdry Process Laboratories, and J. B. Adams and others, of International Minerals and Chemical Corporation, for their assistance in developing and proving the merits of this process.

Literature Cited

1. Happel, J., *Ind. Eng. Chem.*, **41**, 1161 (1949).

Presented at A.I.Ch.E. 47 annual meeting, New York.

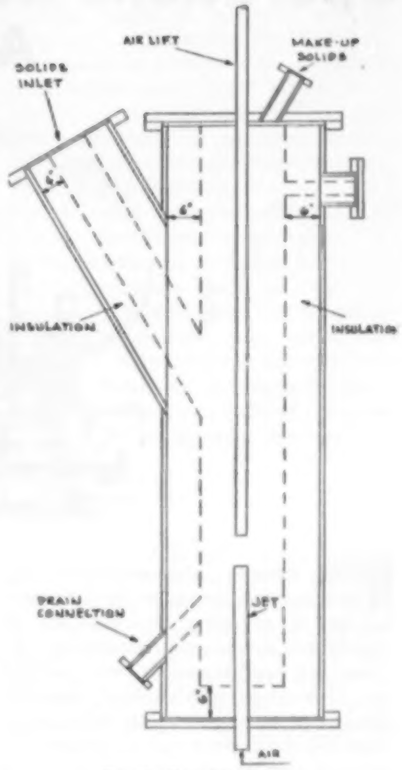


Fig. 4. Engager design.

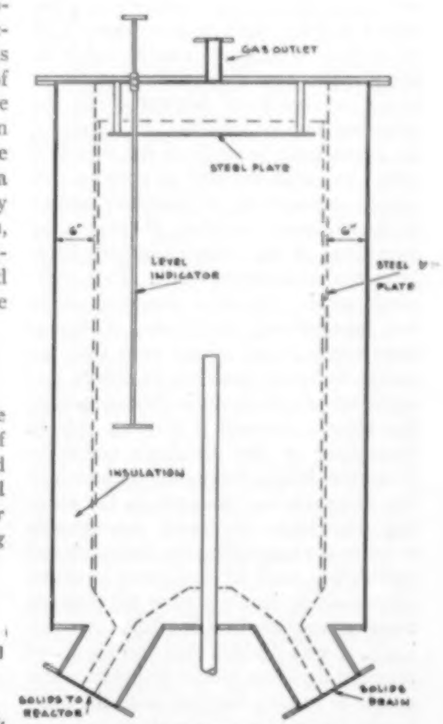
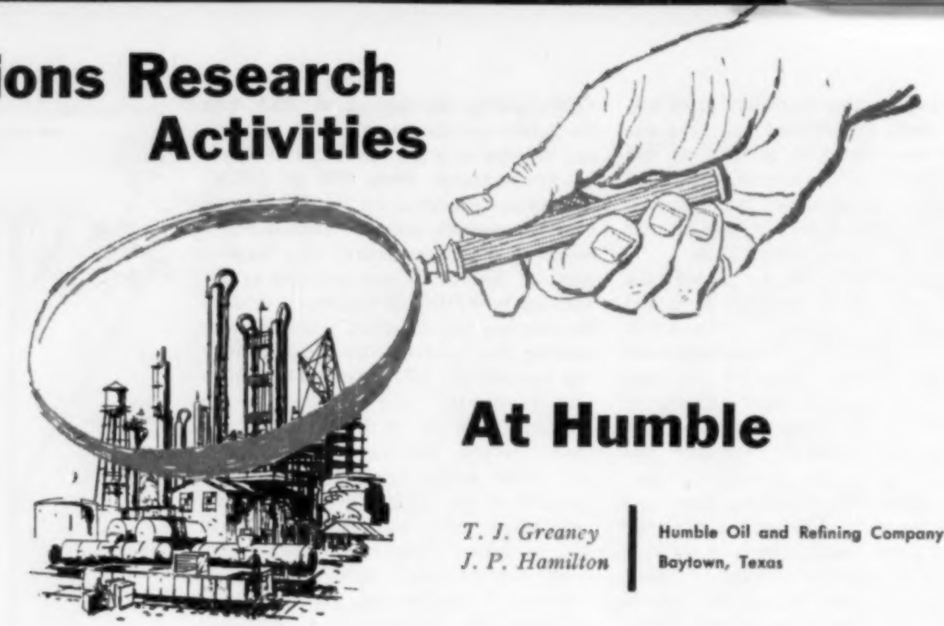


Fig. 5. Disengager design.

Operations Research Activities



At Humble

T. J. Greaney
J. P. Hamilton

Humble Oil and Refining Company
Baytown, Texas

Humble became interested about two years ago in investigating the possibilities of applying the methods of Operations Research in improving efficiency of operations. It was decided that exploration of this subject would be done first in the refining department since this department had a complete integrated staff group with people trained in a large number of scientific fields. The technical staff groups at Humble's Baytown refinery include several hundred engineers, chemists, physicists, and mathematicians in several different staff groups including research and development, engineering, and technical service divisions. All of these staff groups have been applying research methods to some extent in their work in accordance with the definition of operations research as being application of scientific methods to arrive at optimum decisions. In the technical service division, for example, an appreciable portion of the technical effort has been devoted to optimization studies culminating in recommendations to management relative to improving operations of the refinery on both long-term and short-term bases. This technical service division function meets the conventional definitions of operations research and covers more than the purely technical questions of design and operation of equipment in that economics has always assumed a primary role in this phase of the division's activities. However, initial survey of the possibilities of operations research in the refining department indicated considerable promise for expanding the approach and techniques used to determine optimum operations by incorporating the methods more extensively in this effort. Accordingly, it was decided that technical and research divisions would designate a few people to become familiar with the more formal techniques of operations research and establish the applicability of these methods in solving refining department problems.

Initial Activities

The methods which have been used in becoming acquainted with the subject have included several different activities. Personnel participated with affiliated companies in surveying and exchanging information regarding techniques and application of these techniques to specific refining problems. This activity resulted in definition of a number of different specific problems to which certain techniques included in the field had direct application. Representatives participated in two-weeks summer courses conducted at Massachusetts Institute of Technology and Case Institute of Technology. These courses were helpful in obtaining an over-all appreciation of the potentialities for application of methods, in becoming acquainted in some detail with specific techniques, and in defining the literature sources of further information on these techniques. The possible advantages of expanding our use of operations research techniques were discussed with several university professors proficient in this field. Results of these discussions indicated that advantages should accrue to application of these methods to our problems. Two men became acquainted in detail with linear programming procedures by attending a two-weeks course.

At this point it was decided to define two specific major problems important enough to justify assigning adequate technical manpower to apply the methods in the hope of obtaining improved solutions to these problems relative to previous approaches. As an aid in evaluation of the possible methods of organizing our work in this field, it was decided to solve one of these problems independently with our own people and in the other problem to engage the services of an operations research consulting firm to assist in the solution.

The problem we assigned to our own group concerned defining the optimum ratio of catalytic cracking to crude distillation capacity for the Baytown refinery when taking into account the possibility of optimizing seasonal storage of gasoline and heating oil. As this problem developed a number of other closely related operations were also optimized. The group assigned to this work consisted of six members of the technical and research divisions. Three of these people had broad experience in the catalytic cracking field, two were familiar with mathematical and statistical techniques and the third was proficient in over-all refinery economics. In solving the problem defined above, the team established that the most desirable ratio of catalytic cracking to crude distillation capacity was a function of a number of variables, and as a result of this work, it was possible to define the best capacity relationship as a function of heating oil price and gasoline demand when optimizing heating oil and gasoline seasonal storage, average annual heating oil sales, and summer and winter crude charge relationship. All of the variables were optimized for the situation in which seasonal gasoline and heating oil demands were assumed to be variable from season to season, as a function of winter weather severity and general business activity. The studies included evaluation of differences in seasonal transportation costs for these products to the marketing area and storage costs on products seasonally stored.

The study successfully defined the most economic decision regarding installation of catalytic-cracking capacity tak-

ing into account uncertainty on product requirements inherent in the mathematical model of the actual operating problem involved, and in effect, allowed optimum strategy to be followed in the face of these uncertainties. The results of the problem were presented in detail to management to insure their complete understanding of the factors involved, the approach used, and the results indicated. These results were well accepted by management as being a complete evaluation of all the major factors involved and as being sufficient basis for decision.

The second problem on which assistance of a consulting firm was obtained involved definition of optimum oil storage capacity and related operations in the refinery. Two members of the consulting firm proficient in these methods worked in conjunction with three Humble personnel on this problem. The Humble personnel included a physicist, a member of the line organization acquainted in detail with oil-storage operations and facilities, and a chemical engineer experienced in over-all refinery economics and operations. The group established that for purposes of analysis oil-storage capacity in the refinery could be broken down into several major areas which were not, however, completely independent. These areas were crude-storage capacity, intermediate storage capacity between the process units, blending storage capacity, and finished-product-storage capacity. It was found that in each of these categories optimizing oil storage capacity required the best operating strategy on refinery equipment dependent upon the level of storage available in each category. Probability entered into solution of the problem in the form of unit run length, capacity variation and turn-around length, as well as in arrival of tankers for product shipment from finished product storage. Solution of this problem is not complete at present; however, considerable progress has been made in defining the approach to different aspects of this complex interrelated problem. Considerable credit is due to the consultant, first in his method of approaching the problem, and second in his efforts to educate our people working on the problem.

Both methods of approach to applying operations research are considered to be successful. It was found that by choice of proper people in our own organization with some background appreciation of operations research methods, we could solve a problem using these methods and only our own people. It was also found that by the use of less experienced people together with consultant assistance, successful application of the methods could be achieved.

Current Evaluation

It was concluded from these initial activities that application of the methods of operations research has appreciable utility in many refining problems. These methods can be used in the solution of certain complex but well-defined problems existing in a refinery which have not been completely solved previously. Optimum blending of motor-gasoline and aviation-gasoline components using some modifications of linear programming and applying feed-back control from actual plant blending operations should be possible. Definition of optimum operations on complex processes involving independent control of four or more variables such as product requirements, feed availability, or operating conditions simultaneously can be done efficiently by use of the research methods that have been developed for exploration of response surfaces. Evaluation of increased number of variables by these procedures is relatively simple as compared with factorial investigations of these problems involving a large number of variables. Another problem to which these methods should be applicable is establishing optimum mechanical craftsman distribution and scheduling of mechanical work. Application of methods of inventory control that have been developed in the field of operations research should be useful in refinery material storehouse inventory problems and in oil inventory problems.

In addition to these many problems that are well defined, operations research should have considerable utility in assisting in obtaining improved solutions to many complex but poorly defined problems existing in a refinery. Definition of an optimum research program, taking into account probability of success on individual projects and economic reward for this success with limited research facilities and manpower available, should be possible by the use of various combinations of probability and game theory methods with possible use of linear programming to stay within the limitations of research equipment and types of personnel. Optimum distribution of effort in a Technical Service type function between long- and short-term planning, trouble-shooting, and process control should be possible by a research approach. Quantitative definition of the value of flexibility of operations by provision of adequate processing capacity in an optimum manner is another possible field of application. In general, it is concluded that the approach and techniques represent an effective additional tool to be applied in solution of essentially all of a refinery's operational problems.

With regard to personnel qualifications and organization for this work, our opinion at present is that maximum effectiveness would result if men knowing the complex technology of our operations also know the approach, methods, and techniques of operations research. We have concluded that it is more practical to teach these methods to selected capable men in our organization who already know our complex technology obtained through years of experience than it would be to teach our technology to new employees and consultants trained in the methods of operations research. Therefore, we conclude that a relatively extensive training program in this field is in order for our own personnel.

Future Plans

It is planned to expand the training of an appreciable number of our personnel in the basic tools and methods because of the relatively large number of problems to which the techniques are applicable. Both problems which we have approached, and many which we foresee, ultimately require solution on electronic computing equipment, and therefore, we consider it necessary to have a large number of our people able to use modern electronic computing equipment. Statistics and probability enter strongly into many of the research techniques and approaches, and therefore, it is considered necessary to have a wide appreciation of the use of these methods together with an appreciable number of experts in these methods. Certain specific techniques applicable to specific types of problems must be in the command of personnel assigned to these types of problems. Therefore, it is planned to obtain training for these people in specific techniques in connection with their specific problem. Development of models that allow analytical solutions usually requires more sophisticated mathematical training than is normally available in our personnel and, to this end, courses in more advanced mathematics are being conducted.

Various methods of training are available to achieve the aim of having sufficient number of our people proficient in these fields to get wide application of the methods. A two-weeks "Humble Lectures in Science" in operations research has recently been presented by

Professor George E. Kimball of Columbia University. This course, attended by sixteen of our technical people, was well received and it is tentatively planned to repeat such a course in the future. Advanced courses in mathematics are being held and will probably be continued in the future. These courses are available to a major portion of our technical people. It is tentatively planned to have additional "Humble Lectures in Science" covering specific techniques in considerably more detail than was covered in the general course. Another method of training available is having people attend courses offered elsewhere in specific fields of operations research, such as inventory control, production scheduling, and other methods. Our efforts to keep our personnel proficient in use of modern electronic computing equipment will be continued with training programs in use of this equipment. Considerable value has been obtained and will be obtained in the future by exchange of information with affiliated companies on the application of methods to their problems. Participation in activities of operations research societies such as the Operations Research Society of America and The Institute of Management Sciences is an effective way of keeping up with progress in this field.

With regard to the use of consultants in this field, our present feeling on application of operations research to refining is that consultants should be used in discussing the approach to an operations research problem and to obtain assistance in specialized techniques to be applied rather than in having them assist us in actual solutions of our problems. This approach to the use of consultants is not necessarily the proper one if an organization has less complete technical coverage of the operations than is available in the Humble refining department.

Summary

It is concluded from our initial survey of the possible application of these methods to a refinery that sufficient credits accrue to application of these methods to justify an expanded attempt to apply these methods widely in our refinery. Our work to date in this field has given us confidence that many problems which were known to exist and had never been approached previously can be solved effectively and successfully by our personnel.

Acknowledgment

The writers wish to express appreciation to the Humble Oil & Refining Company for permission to write this paper.

Contents of Symposium Series Volume 51

Summaries of remaining papers from "Mass Transfer—Transport Properties," Series 16, Vol. 51. Others were published in September.

Simultaneous Heat and Mass Transfer in a Nonisothermal System: Through-Flow Drying in the Low-Moisture Range

W. B. Van Arsdel

A basic theory of the behavior of through flow driers, both batch (unsteady state) and continuous (steady state), is developed for the special case in which the rate-controlling factor for drying is internal diffusional resistance in the material. The system differs in characteristic ways from a simple heat-transfer system or an isothermal mass-transfer system. Examples of computation techniques are given.

Gas-Film Mass Transfer in a Packed Column

Fumitake Yoshida

The main objectives of the present work were, first, to see whether mass or linear velocity should be considered as the main factor controlling the gas-film mass transfer in packed columns and, second, to check the exponent on the Schmidt number. Experiments of adiabatic vaporization of water into three carrier gases, helium, air, and carbon dioxide, were performed in a 4-in. column packed with 1-in. Raschig rings, covering the ranges of G from 27 to 1,000 and L from 500 to 6,000.

Fluid Mechanics and the Transport Phenomena

R. B. Bird, C. F. Curtiss, and J. O. Hirschfelder

Many of the current research problems in chemical engineering concern the simultaneous transfer of heat and mass in flow systems, sometimes further complicated by chemical reactions. Such flow problems are described by the "equations of change" of fluid mechanics. These basic differential equations form the starting point for the development of a number of topics of direct interest to chemical engineering science which cannot be solved analytically. Because of the paramount importance of the equations of change in basic chemical engineering studies, these equations are summarized here in their most complete form and the major relationships among the equations of change, the flux vectors, the transport coefficients, and the forces between molecules are pointed out.

Thermal Diffusion in Liquids

H. G. Drickamer and W. M. Rutherford

The principles of thermal diffusion are outlined, especially as applied to liquids, and its uses for studying intermolecular forces and for making special separations are discussed. The mechanics of the single-stage system, useful for quantitative measurement of the thermal-diffusion ratio, and the thermal-diffusion column, useful for practical separations, are outlined. Certain specific results which illustrate the power of the method are discussed.

Viscosity of Gases and Gas Mixtures at High Pressures

N. L. Carr, J. D. Parent, and R. E. Peck

This paper presents methods for the prediction of the viscosity of gases and gas mixtures over the practical range of pressure, temperature, and phase composition encountered in moderate and superpressure operations. The methods were developed from and based primarily upon the determination of the dynamic, absolute viscosity of certain gases up to pressures of 10,000 lb./sq.in. over a temperature range of 70° to 250° F.

Mass Transfer Inside Drops in a Gas

R. R. Hughes and E. R. Gilliland

Many types of gas-liquid contacting devices, such as plate columns and spray chambers, use contact surfaces formed by the temporary dispersion of one phase within another. As an experimental simplification of this type of system, individual streams of drops or bubbles can be used. This paper reports a study of the inside resistance to mass transfer in drops of water falling through nearly pure carbon dioxide gas.

Tests were made at 6.5°, 25°, and 45° C., and with 2.5-, 3.5-, and 5-mm. drops. Drops were formed at several rates between 30 and 200/min., and allowed to fall through various heights from 2.5 to 165 cm., the results being corrected for transfer both during formation and during collection under kerosene.

From the corrected data both mass transfer coefficients and effective eddy diffusivities were calculated. The best correlation corresponds to an exponential decay of mass transfer coefficient with time. Since this decay rate matches the theoretical decay rate for oscillation, the experiments seem to show a proportionality between the mass transfer coefficient and the oscillation amplitude.

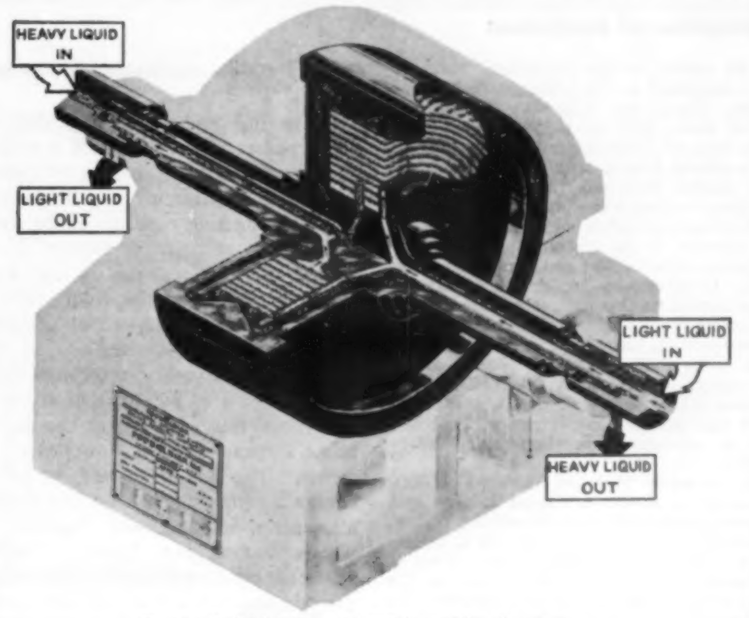


Fig. 1. Podbielniak model 9500 centrifugal extractor.

COMMERCIAL EXTRACTION OF unfiltered fermentation broths IN THE PODBIELNIAK CONTACTOR

D. W. Anderson and E. F. Lau

Parke, Davis and Company, Detroit, Michigan

The application of centrifugal extractors in the pharmaceutical industry is no longer new. Until recently, however, only liquids containing small amounts of suspended solids could be effectively handled in units such as the Podbielniak centrifugal contactor. Recently engineers at Podbielniak, Inc. have developed a unit which will process liquids containing up to 10 to 15% solids (*1*). Parke, Davis and Company pioneered the successful application of this unit in the extraction of unfiltered Chloromycetin fermentation broths as early as 1951.

The apparatus of Podbielniak (*8-14*), first developed in 1934, consisted essentially of a spinning rotor, mounted horizontally, containing a perforated spiral through which two liquids of different densities were passed continuously and countercurrently. This innovation found little commercial application until the advent of large-scale fermentation of penicillin during World War II. The extractor was especially suited to the extraction of penicillin since small density differences and short contacting times were essential. The use of this type of equipment spread rapidly throughout the pharmaceutical industry within the United States and abroad where it found wide application in the processing of antibiotics (*4, 6, 7*). Recently the field of application has broadened to include certain chemical, petrochemical, and refinery operations.

Published data on performance and operating characteristics of the Podbielniak extractor were not available until Bartels and Kleiman (*3*) and Barson and Beyer (*2*) reported their results. Barson and Beyer presented studies performed in the Podbielniak laboratory Pup model on the ternary system boric acid-isoamyl alcohol-water. This laboratory unit handled a maximum throughput of 7 gal./hr. compared to commercial size units that can now process up to 25,000 gal./hr.

It is the purpose of this paper to make available to industry actual production performance data, operational characteristics, and a cost analysis of the Podbielniak centrifugal contactor (Models 9000 and 9500). This experience has been gained over a period of one and one-half years in the extraction of Chloromycetin from whole fermentation broths. Data will be presented also on the limited application of the 9500 unit in the extraction of whole penicillin broths.

Description of Equipment

Two models of the centrifugal contactor were employed in the antibiotic division of Parke, Davis and Company during the period from 1951 to 1953 for the direct extraction of Chloromycetin and penicillin fermentation broths on a production scale. The Model 9000 was the unit originally designed to handle liquids containing 10 to 15% suspended solids and was used fairly successfully in the extraction of Chloromycetin broths in 1951 and the early part of 1952. However, as production experience accumulated on this unit, it became evident that certain changes in design were needed to improve the extraction efficiency and the flow of the solids containing phase through the rotor. Consequently, Podbielniak engineers redesigned the unit. The new model 9500 was installed in September, 1952, and was in continuous operation until January 1, 1954.

A cut-away view of the Model 9500 extractor is shown in Figure 1. The unit consists essentially of an all-welded, hollow, stainless-steel rotor mounted on a central shaft. The rotor is made up of a series of concentric metal strips which act as the contacting elements and are systematically perforated to permit countercurrent passage of the two phases between the center and the periphery of the rotor. The rotor also contains specially placed ports to permit passage of the entering and exit streams.

The earlier 9000 model differed from the unit shown in Figure 1 in several respects such as (1) a smaller rotor diameter (21 in. compared to 25 in.), (2) the absence of a solids deflecting baffle, (3) a smaller clarifying zone at the periphery of the rotor, (4) nature of inlet and outlet ports, and (5) smaller perforations in the contacting elements.

Contacting and separating the two liquid phases, either of which may contain suspended solids, is effected continuously and countercurrently in the perforated contacting elements of the rotor. As can be seen from Figure 2, the lighter of the two phases is introduced at the periphery of the rotor, and the heavier phase is introduced at the center. The centrifugal force imposed on each phase by the spinning rotor causes the heavier liquid to flow to the outside of the rotor thus displacing the lighter phase and causing it to flow toward the center. The action of the perforated contacting elements within the rotor is alternately to mix and separate the phases in multistage fashion. Calming zones near the center and at the outside provide clarification of both streams as they leave the rotor. Streams are conveyed to and from the rotor through passageways in the central rotating shaft. Specially designed mechanical seals located at each end of the central shaft permit the passage of each stream through stationary piping to or from holding or supply tanks.

Centrifugal force, ranging from 2,000 to 5,000 times the force of gravity, permits satisfactory handling of the two phases with as little as 0.02 sp. gr. difference. By suitably adjusting the back pressure in the light-liquid-out stream, the relative volumes of heavy and light phases in the rotor can be controlled independently of flow ratios. Rotameters are used on all but the heavy-liquid-out stream. Comparison of light-liquid-in and out rates indicates the amount of solvent being lost in the heavy-liquid-out as emulsion or in solution.

The Model 9500 extractor is designed with a V-shaped solids deflecting baffle so that the solids fed can be more easily discharged in the heavy liquid leaving the rotor. However, the solids encountered in Chloromycetin and penicillin extractions tended, nevertheless, to accumulate at the periphery of the rotor. This undesirable condition was alleviated by maintaining a high rate of flow of the heavy liquid. The resulting high degree of turbulence created in the heavy liquid stream opposes the centrifugal force tending to cause the solids to lodge in the rotor. However, build-up of solids to a certain degree will occur on continuous operation. This may result in an unbalanced condition in the rotor. It may be necessary, therefore, whenever there is evidence of excessive vibration due to an unbalanced build-up of solids, to flush the rotor with high pressure water. To compensate for these vibration characteristics, the unit can be mounted on a spring-supported concrete base.

Operating Characteristics

VARIABLES

In evaluating the production performance of the extractors, it was important that consideration and attention be given to all the variables involved. These variables were grouped into two general categories, namely (1) those having an indirect effect on extractor operation and (2) those having a direct effect on extractor operation.

The indirect variables were introduced during the fermentation operation and significantly affected the condition of the broth fed to the extractors. These included strain, media formulation, and length of the fermentation cycle. Although these particular variables were generally fixed for a series of production fermentations, there remained numerous unpredictable lot-to-lot variations that were for the most part uncontrollable. Hence, successive lots of fermentation broth may have varied considerably in (1) character and amount of solids, (2) quantity and composition of defoamer, (3) type of enzymatic reactions occurring during the fermentation process, and (4) character of the natural media ingredients used. Such variables are inherent in any commercial fermentation. Production runs were selected for evaluation in such a way as to minimize the effect of these uncontrollable variations.

The direct variables were introduced in the extraction operation itself and were rigidly controlled. These variables were:

1. Rotor speed
2. Flow ratio of broth (heavy-liquid-in) to solvent (light-liquid-in)
3. Total throughput rate of combined liquid streams
4. Ratio of the two phases in the rotor

Perhaps the greatest effect of rotor speed on extractor operation is related to the centrifugal force developed in the rotor. This effect is accentuated in view of the solids suspended in the broth phase. As the rotor speed is increased, the suspended particles tend to accumulate first at the extreme periphery of the rotor and then gradually in the outer contacting elements. When this deposition occurs in the contacting elements, the number of effective mechanical contacting stages is progressively lowered. On the other hand, the greater centrifugal force developed, as the rotor speed is increased, will tend to break any emulsion that persists in the contacting elements and/or the clarifying zone. The problem of rotor speed selection then becomes one of balancing these two effects to obtain maximum extraction efficiency.

The proper selection of the most advantageous broth-to-solvent ratio depends primarily on the distribution coefficient of the system involved. Generally, the higher the distribution coefficient, the greater is the ratio of broth-to-solvent that can be used. However, for any specific system, lowering this ratio will usually result in progressively higher extraction efficiencies. Other factors played an important part in selecting the most effective broth-to-solvent ratio. First, variations in the broth-to-solvent ratio can cause rather marked variations in the emulsifying tendencies of the two phases. In both systems studied high ratios resulted in troublesome emulsification problems. Second, the use of a high ratio will result in the processing of smaller solvent extract volumes. Solvent losses and processing labor in subsequent recovery steps thus should be materially reduced with appreciable economies being realized.

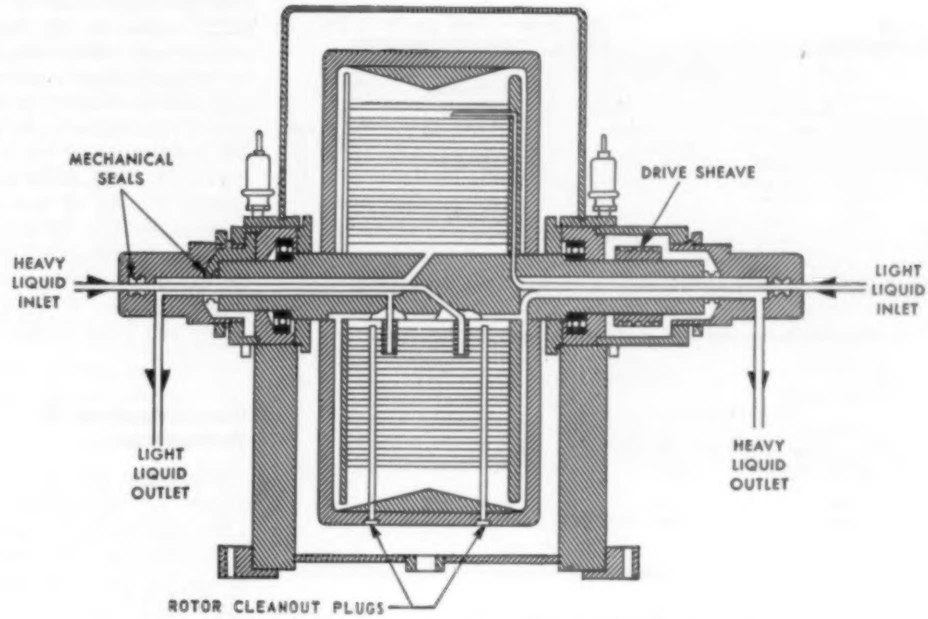


Fig. 2. Diagram illustrating operation of model 9500 solids handling extractor.

Finally, it should be borne in mind that for a fixed total throughput rate changes in the ratio will affect the relative contact time of the two phases in the rotor. If contact time is critical, this factor may affect over-all extraction efficiency.

When selecting the optimum total throughput rate, several factors are important. In the extraction of unclarified broth, it is advantageous to use the maximum throughput rate attainable in the extractor. The use of a high rate will assure maximum turbulence of the solids in the broth phase, thereby reducing the tendency for solids build-up in the rotor. High throughput rates will also provide better dispersion of the two phases as they pass through the perforations in the contacting elements, thus increasing the available area for mass transfer of the solute into the solvent. On the other hand, this increased dispersion and more violent mixing action will favor emulsification with its associated problems. Finally, higher throughput rates will decrease the time that the two phases are in intimate contact within the rotor. This effect may reduce extraction efficiency.

Regarding the ratio of the two phases in the rotor, the manufacturer recommends that the rotor should be kept full of the liquid having the lower flow rate in order to obtain the highest number of extraction stages. The authors' past experience with the extraction of clarified Chloromycetin broth showed this to be true. Standard operating procedure required that maximum back pressure be maintained in order to obtain maximum extraction efficiency. However, in the extraction of whole Chloromycetin and penicillin broths this condition could not be fulfilled at all times. Because of emulsification and a reduction in the effective broth clarifying zone at the periphery of the rotor due to solids build-up, it was not feasible to maintain the optimum amount of solvent in the rotor. Back pressure had to be reduced in order to prevent spill-over of solvent and emulsion into the heavy liquid-out stream. This restriction in the operating range of the back pressure will tend to lower extraction performance.

SPECIAL PROBLEMS

Several times in this discussion reference has been made to the emulsifying tendencies encountered in whole broth extractions. The manufacturer predicted that emulsification may create a major problem in the efficient operation of the solids-handling extractor. Initially, therefore, considerable study was given to the appraisal of various wet-

ting agents for their effect in reducing emulsion formation. Arquad-C, Demulso No. 1, Ultrawet 30DS, and Nopco 1025-B were among those tested. As experience was gained in the operation of the unit, it developed that sufficient emulsion control could be obtained in the majority of cases merely by the proper selection of extractor operating variables. However, it is recognized that because of wide variation in broth characteristics it may become necessary to resort to wetting agents for the control of severe emulsification problems.

In the extraction of clear liquids the length of the operating cycle is not a limiting factor. In fact Podbielniak, Inc. has reported instances in which units have been in operation for 9,000 hr. without attention. However, introduction of solids into the extraction operation presents the problems of vibrational effects and reduction of the operating cycle.

At the beginning of the extractor cycle an initial build-up of solids always occurs even under the most ideal conditions of optimum rotor speed and maximum throughput rate. However,

Table 1.—Comparison of Clarified and Whole Broth Extraction Performance

Strain = A
Rotor Speed = 3400 rev./min.
Throughput = 1860 gal./hr. ± 5%
Extractor = Model 9000

Broth Condition	Broth/Solvent wt. ratio	No. Theor. Stages	Extraction Efficiency %	No. of runs
Clarified	3.48	1.33	89.6	17
	4.14	1.22	85.0	12
Whole	2.51	0.94	85.5	6
	3.06	0.90	78.0	7

Table 2.—Performance Comparison of Model 9000 and 9500 Extractors

Strain = B
Throughput = 2120 gal./hr.
Broth/Solvent wt. ratio = 3.10

Extractor Model	Rotor Speed rev./min.	No. Theor. Stages	Extraction Efficiency %	No. of runs
9000	3300	1.30	90.3	59
9500	2900	2.03	97.0	55

the rate of build-up diminishes rapidly, and further accumulation is curtailed by the increased velocity of the heavy liquid at the periphery of the rotor. Normally, this build-up of solids occurs evenly around the periphery, and the rotor remains dynamically in balance. Vibration is thereby kept at a minimum. As the extraction continues, erosion of the existing solids ring by the heavy liquid stream may occur and subsequent uneven deposition of solids may upset the rotor balance. If the resulting vibration becomes excessive, it is necessary to shut off the inlet streams, slow down the rotor, and flush out the deposited solids with high pressure water. Although it was felt initially that these intermittent flushings might limit the continuous operation of the unit, experience at Parke, Davis and Company showed that up to 6000 gal. of either Chloromycetin or penicillin broths could be handled in 4 to 6 hr. without the need for periodic shutdowns.

Physical and Equilibrium Data

CHLOROMYCETIN

Whole Chloromycetin fermentation broth as fed to the extractor contained mold mycelia, undigested nutrient solids, and dissolved materials including the antibiotic. The total solids content averaged 2.5% by weight. Most of the undissolved solid matter was cellular in nature and occupied 8 to 10% of the volume of the whole broth. The specific gravity of the whole broth measured approximately the same as water. Recovered Pent-Acetate (Sharples), which is practically immiscible with water and has a specific gravity of 0.86 – 0.87 at 20° C., was the extracting solvent. The distribution coefficient for Chloromycetin between water and recovered Pent-Acetate was found to be 16.1 at room temperature. The value is substantially independent of concentration.

PENICILLIN

The whole penicillin broths which were processed had an average total solids content of 8% by weight. The undissolved solids averaged 20 to 30% by volume after centrifugation. This high solids content produced an apparent viscosity at room temperature of 230 centipoises at 60 rev./min. with the use of a Brookfield viscometer. The specific gravity of the broth was approximately that of water. Pent-Acetate was the extracting solvent. Penicillin has a distribution coefficient of 27 at *p*H 2.5 and 5° C. with respect to water and Pent-Acetate (*5*).

Determination of Performance

Extraction efficiency was used as a gauge of performance on all the Chloromycetin and penicillin runs made. This efficiency was expressed as 100 minus the per cent unextracted from the feed or heavy-liquid-in stream.

As an additional measure of performance, the number of theoretical stages of extraction (N) was determined analytically by the method of Underwood (*15*). The equation

$$Z_N = \frac{E-1}{E^{N+1}-1} \qquad (1)$$

where

$$E = \frac{\text{distribution coefficent}}{\text{broth-to-solvent ratio}}$$

Z_N = fraction unextracted after the Nth stage

holds for countercurrent extractions where the two liquids are immiscible, where the distribution coefficient is independent of concentration, and where the incoming solvent is free of solute. These conditions exist or are assumed. Except for penicillin, the broth-to-solvent ratio was determined by material balance from the stream concentrations.

Table 3.—Effect of Broth-to-Solvent Ratio on Extraction Performance

Throughput = 2120 gal./hr.
Extractor = Model 9500

Strain	Broth/Solvent wt. Ratio	Rotor Speed rev./min.	No. Theor. Stages	Extraction Efficiency	No. of Runs
B	4.43	2900	1.82	93.0	8
	4.03	2900	1.90	94.8	8
	3.92	2900	1.87	94.6	8
	3.40	2900	2.04	96.6	9
	3.20	2900	2.03	97.0	55
	2.66	2900	2.08	98.1	9
	2.36	2900	2.21	98.8	12
C	2.62	2700	1.17	89.8	41

Performance Data

CHLOROMYCETIN

The first whole broth extraction runs carried out at Parke, Davis & Company in the Model 9000 extractor were made with Strain A broths. In the process of conversion to whole broth extraction, a number of runs were also made on clarified broth. It is interesting to refer to these in order to draw a comparison between whole and clarified

broth in the same extractor. These runs are compared in Table 1. Though the broth-to-solvent ratios for the clarified and whole broth are not specifically comparable, the efficiencies and number of stages are still significantly higher for the clarified runs. This is true despite the fact that the performance on clarified broth would be expected to be lower at the higher ratio reported. This difference is probably attributable to the greater tendency of whole broth to emulsify and to the interference of the solid matter in mass transfer and diffusion.

Two series of runs made with Strain B broths were selected for the purpose of comparing the performance of the Model 9000 and 9500 extractors. The difference in results obtained on the two units with this type of broth is shown in Table 2. The two models have different diameters and therefore must be operated at different rotor speeds under optimum conditions. The improvement in the number of stages and in the extraction efficiency seen here is a result of the design of the units. The 9500 unit has greater clarifying space, gentler action because of the larger perforations and lower speed, and more efficient solids handling.

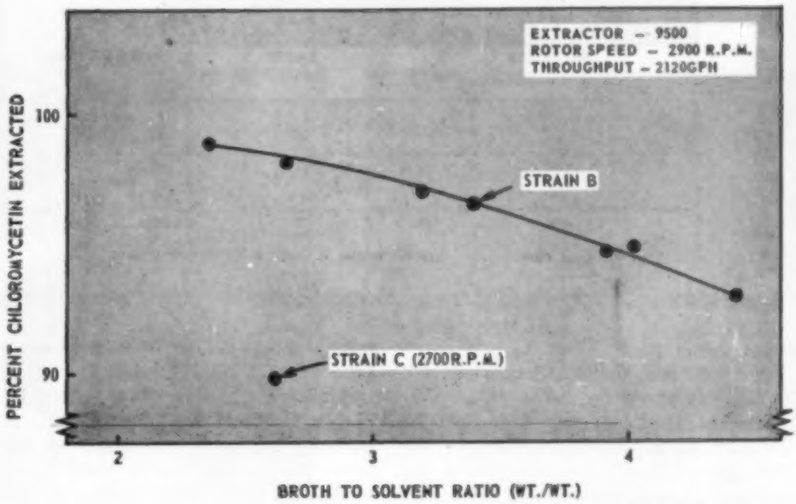


Fig. 3. Effect of broth-to-solvent ratio on extractor performance.

Table 4.—Effect of Rotor Speed on Extraction Performance

Strain = B
Broth/Solvent wt. Ratio = 3.57 ± 5%
Throughput = 2121 gal/hr.
Extractor = Model 9500

Rotor Speed rev./min.	No. of Theor. Stages	Extraction Efficiency %	No. of Runs
2300	2.36	97.5	8
2500	2.31	97.8	8
2700	2.19	96.8	8
2900	2.04	96.6	9

A number of runs were made in the 9500 extractor over a range of broth-to-solvent ratios with the use of Strain B broths. These are tabulated in Table 3 along with one group of runs made with Strain C broths. These data are plotted in Figure 3. It can be seen that there is a decrease in the extraction efficiency as the broth-to-solvent ratio is increased. For true theoretical stagewise countercurrent extraction, there would be little, if any, change in the number of stages produced as the ratio changes. Here, however, due to the nature of the extraction apparatus and the effects of emulsification, stages also are reduced as broth-to-solvent ratio is increased. As shown in Figure 3 the performance on Strain C broths is inferior to Strain B. This gives a rather dramatic indication of the effect of strain changes upon whole broth extraction performance.

Several sets of runs were made also with varying rotor speeds as a part of the determination of optimum conditions for the 9500 extractor. These runs were all made with Strain B broths. Data are tabulated in Table 4. The effect of rotor speed on extraction performance is actually not very great over the range covered in this work.

equipment

PENICILLIN

Experience with the extraction of whole penicillin broths was by no means as extensive or as successful as with Chloromycetin broth. Because of the higher undissolved solids content these broths had a higher apparent viscosity and were a good deal more difficult to handle from the standpoint of solids accumulation and emulsion. Stripping of the spent broth was necessary for recovery of the solvent. This was required for Chloromycetin runs also, but solvent losses were lower. The results that are reported are merely a general indication of performance because of the limited number and range of variables covered.

Penicillin whole broth was extracted only in the 9500 unit. Soon after the beginning of this operation, a check was made on clarified broth extraction in order to establish a point of reference. Extraction efficiencies of approximately 95% were achieved on the check runs with Pent-Acetate as the solvent.

It soon became obvious in the initial whole broth extraction runs that a single pass through the extractor did not provide adequate contact time for extraction of penicillin from the broth. In view of the fact that these efficiencies averaged 65%, re-extraction of the raffinate stream was begun. Because only one extractor was available and to avoid the necessity of pH adjustment, the re-extraction was done on a half-hour cycle so that the accumulated raffinate did not stand too long at low pH.

In view of the large amounts of acid required for adjusting the pH of the whole broth, the variation in acid requirements was large enough to cause significant variations in broth-to-solvent ratio and in throughput. Thus in organizing the production runs for tabulation, it was necessary to group them according to ratio and hence, according to throughput. A number of such groups are presented in Table 5 for runs in which re-extraction of the raffinate was employed. In this table, actual broth-to-solvent ratio is used because of the rather poor material bal-

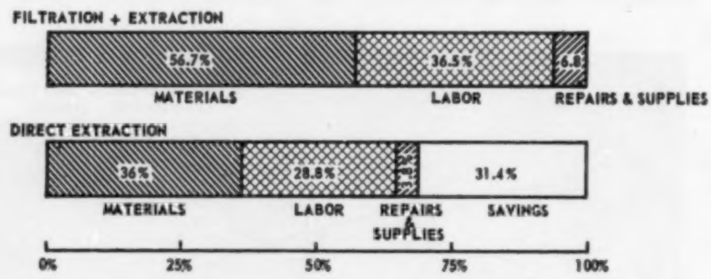


Fig. 4. Cost comparison, filtered broth vs. whole broth extraction.

ances found in these runs.

It can be seen that approximately one half of a theoretical stage or an efficiency of approximately 65% can be achieved on a single pass through the 9500 extractor. By re-extraction of the raffinate stream, the over-all extraction efficiency can be increased to approximately 85%. The increased contact time of solvent and broth caused this improvement which was reflected in higher yields of the final product. Apparently the effect of operating variables on performance is small enough to be obscured by the limits of accuracy of the data.

Cost Comparison

Considerable discussion has been given to an evaluation of the operating characteristics and performance of the Models 9000 and 9500 extractors. Of equal importance from a manufacturing standpoint is the consideration of operating costs. The authors realize that their experience with these units has been restricted to a specific application. However, a cost comparison of the extraction of Chloromycetin whole broth with the more conventional two-step process of filtration and extraction may be of value to others who are contemplating use of this special piece of equipment.

As a basis for this cost comparison a normal three-month operating period was selected for each type of processing. The average monthly broth potency for each period varied by only 1.0% and all other steps in the processing of these fermentation broths remained unchanged. A summary of the individual costs for each type of processing is shown schematically in Figure 4. Normal burden items were not affected and hence did not enter into the comparison.

A 31.4% decrease in processing costs was achieved by converting to the direct extraction of whole fermentation broth. This reduction was made possible primarily through the elimination of the filtration step since large quantities of filter aid and acid used to precondition the broth were no longer required. Costly filter maintenance and labor required for the operation of these filters were also eliminated.

In addition to the above direct savings, the over-all yield of purified Chloromycetin increased 10% after conversion to whole broth extraction. The decrease in operating costs and increase in product yield lowered the out-of-the-pocket unit cost of finished Chloromycetin by 18%.

Table 5.—Performance of Model 9500 Extractor on Whole Penicillin Broth

Strain = Wisc. 51—20
Rotor Speed = 2700 rev./min.
Extractor = Model 9500

Actual Broth/ Solvent wt. Ratio	Throughput gal./hr.	Extraction Efficiency %	No. Theor. Stages	No. of Runs
First Extraction				
3.39	1870	66.0	0.53	8
3.63	1910	59.0	0.43	9
3.85	2047	70.4	0.57	9
4.06	2080	59.3	0.42	5
Re-extraction				
4.55	2032	50.3	0.36	5
4.86	2125	65.0	0.54	10
5.11	2220	64.0	0.53	7
5.33	2300	71.8	0.68	5

Comments

Under actual production conditions Chloromycetin whole broth was handled very successfully by the 9500 unit. Significant economies were realized as a result of high extraction efficiencies and a reduction in process labor and maintenance.

The marked effect of strain on performance, however, brings out the frequent need for re-evaluating operating variables and/or design of the extractor when changes in the fermentation process occur.

The limited application of the 9500 unit to penicillin whole broth extraction was less successful. The results achieved with re-extraction emphasize the need for adequate contact time when dealing with broths of this type.

Acknowledgments

The authors wish to express their appreciation to Parke, Davis and Company for permission to publish this information. They also are indebted to Podbielniak, Inc. for photographs, drawings and other assistance, and to H. G. Donnelly, chairman, department of chemical engineering, Wayne University, for guidance. Finally, the authors wish to acknowledge the help of several of their colleagues at Parke, Davis and Company: Messrs. S. A. Bela, P. G. Jacobs, H. F. Jensen, K. N. Larsen, and R. J. Simsick for technical assistance and D. G. Lockhart for unpublished Chloromycetin equilibrium data.

Literature Cited

1. Angelo, N. J., (to W. J. Podbielniak and W. G. Podbielniak), U. S. Patent 2,652,975 (Sept. 22, 1953).
2. Barson, N., and G. H. Beyer, *Chem. Eng. Progr.*, **49**, 243 (1953).
3. Bartels, C. R., and G. Kleiman, *Chem. Eng. Progr.*, **45**, 589 (1949).
4. Chloromycetin Production, *Chem. Eng.*, **56**, 172 (1949).
5. Feder, R. L., Master's Thesis, Polytechnic Institute of Brooklyn (1947).
6. Inskeep, G. C., *et al.*, *Ind. Eng. Chem.*, **43**, 1488 (1951).
7. Penicillin, *Chem. Eng.*, **58**, 174 (1951).
8. Podbielniak, W. J., U. S. Patent 2,003,308 (June 4, 1935).
9. Podbielniak W. J., (to L. W. G. Podbielniak), U. S. Patent 2,044,996 (June 23, 1935).
10. Podbielniak, W. J., U. S. Patent 2,093,645 (Sept. 21, 1937).
11. Podbielniak, W. J., U. S. Patent 2,109,375 (Feb. 22, 1938).
12. Podbielniak, W. J. (to B. B. Schneider), U. S. Patent 2,172,222 (Sept. 5, 1939).
13. Podbielniak, W. J. (to B. B. Schneider), U. S. Patent 2,281,796 (May 5, 1942).
14. Podbielniak, W. J. (to B. B. Schneider), U. S. Patent 2,286,157 (June 9, 1942).
15. Underwood, A. J. V., *Ind. Chemist*, **10**, 128 (1934).

Presented at A.I.Ch.E. 47th annual meeting, New York.

Spillage vs. Runaway

This . . . . . . or this—which represents the most likely financial risk in your nuclear operations future?

THE PROBLEM OF insuring nuclear installations

Mathew M. Braidech | National Board of Fire Underwriters, New York.

The idea that risk is the essence of business and that the financial risks of private enterprise form the foundation of our modern society is inherently sound. But for the individual entrepreneur risk can work to retard progress if it is not reasonably minimized or spread out over many single ventures. This is the job of insurance which in its various forms can also be regarded as an essential cog in our nation's intricate industrial and business mechanism.

Photos courtesy, l. to r., G.E.; Argonne.

Our traditional competitive-enterprise system and our technological advancement could not have been possible without some safeguarding of our economic incentives. As science progressed through industrial applications of its fruits, the protective coverage of insurance advanced with it, meeting an ever-increasing variety and multiplicity of situations that accompanied every major economic advancement.

Atomic energy—a challenge to insurance

The problem of protecting physical and business assets in connection with current private efforts in atomic energy developments presents a special challenge, to both the engineering profession and the insurance business. During the nine months that have elapsed since the official existence of the Atomic Energy Act of 1954, there is considerable evidence that the commercial development of nuclear power within the United States is successfully pulling through a whole series of technical bottlenecks and is proceeding toward practical reality. Among final obstacles which temporarily bar the way

In March, 1954, the U. S. Atomic Energy Commission appointed ten insurance executives to consider insurance problems in providing protective coverage for private reactor operations and other civilian atomic energy developments. This insurance-study committee was selected to represent casualty, liability, surety, and fire and explosion interests from the leading capital stock and mutual companies. It comprised the following personnel:

Donald H. Burr, secretary, Aetna Casualty & Surety Company; Charles J. Haugh, vice-president, Travelers Insurance Company; H. C. Jones, president, Arkwright Mutual Fire Insurance Company; H. W. Yount, vice-president, Liberty Mutual Insurance Company; A. L. Papenfuss, vice-president, Employers Mutual Liability Insurance Company of Wisconsin; W. B. Weber, vice-president, Lumbermens Mutual Casualty Company; Percy Chubb, president, Federal Insurance Company; K. E. Black, president, Home Insurance Company; Manning W. Heard, 1st vice-president & general Counsel, Hartford Accident and Indemnity Company; A. B. Jackson, president, St. Paul Fire and Marine Insurance Company. Percy Chubb is chairman, and Mathew M. Braidech, director of research, National Board of Fire Underwriters, has been designated secretary.

These executives received security clearances and were to be provided with needed classified information to carry out the following program of work:

(a) To review insurance problems created by expanded industrial participation in atomic energy, and

(b) To develop information and criteria with respect to the insurability of industrial atomic energy installations and undertakings.

(c) To make appropriate recommendations to the Commission including any specific legislation.

After visiting a number of key facilities at various A.E.C. locations over a three-month period, the group submitted an interim progress report outlining the problems of insurance and the type of coverage to be provided, as well as the need for study of the capacity of the commercial market and government participation in excess insurance to cover catastrophe losses. The committee also recommended a continuing study program between the insurance industry and the A.E.C. at an engineering level for proper risk evaluation and production of suitable codes and standards. A preliminary report covering these items was released by the A.E.C. on July 13.

are primarily legal knotholes concerning the important questions of licensing and regulation and the assumption of insurance risks. The simplified clearance system, recently instituted by the Atomic Energy Commission, will give access to much-needed information to responsible industrial groups on the solutions of problems associated with commercial utilization of atomic power. This action will expedite also for the insurance and underwriting groups the technical analysis and rational assessing of risks and perils to be involved in the different types of proposed nuclear reactors.

To assure the fullest cooperation, there is a need for a better understanding of the respective problems and attitudes among engineering experts, business authorities, and insurance specialists.

Dangerous products are commonplace today

We are now entering a new, rapid-growth cycle in our expanding technological era, where hazardous materials are being used in extremely large quantities and with processing operations that are being conducted at increasingly higher temperatures and pressures with greater and greater throughput volume of dangerous products. More and more of these processes are being classified in the extrahazardous category. However, it is recognized that in well-managed modern plants having such high order of calculated risk, there is compensation in the main by good technical know-how to the extent that the financial risk, because of "controlled" accident potentials, is quite often considered not too excessive. Since such industrial systems are provided with capable supervising talent at all levels, and good design and built-in safety features in terms of interlocks and automatic instrumentation, and periodic inspections and preventive maintenance programs, they are favorably regarded as insurable.

Scientific advancement and rapid industrial progress are having an impact on every phase of human endeavor. The insurance business is one of those segments of our economy that consequently is becoming increasingly complicated because the changes of today are creating a broad gamut of damage protection under almost every kind of situation. Experience is the only sound basis for insurance, however, in the absence of factual loss situations, judgment has often been found to be a satisfactory resort—if only on a temporary basis —for early coverage of new developments. Where there is potential for widespread damage with consequent, enormous monetary losses, more conservative attitudes are generally resorted to in terms of limits of insurance coverage and demands for standards, to minimize unsafe conditions for design, installation, operation, inspection, and maintenance. In this manner many difficult and almost insurmountable insurance coverage and safety protection problems have been satisfactorily resolved.

Insurance and Commercialization of Nuclear Power

The problem of gradual and safe transfer of the world's greatest governmental monopoly into private enterprise presents as difficult a matter as the technical study of obtaining economical and plentiful nuclear power. One of the major problems in this connection is the matter of insuring against atomic risks from private ownership and commercial operation of nuclear power reactors because of the enormous risks which may be incident to serious reactor accidents. The problem becomes all the more difficult and challenging because nothing is available to forecast liability and no formula is possible for calculating such loss potentials; insurance, therefore, can resort justifiably to good guesses in any such large areas of uncertainty, similar to engineering approaches with safety factors. The problem is complicated even further by the fact that a good number of different types of reactors have been proposed for atomic power plants. There has been little or no standardization of any type of reactor at this stage, and none of the proposed systems studied can yet produce economic or competitive central-station power today—a good many designs are still in the conceptual stage.

Insurance Study for A.E.C.

To review properly the insurance problems created by the expanded industrial participation in the development of atomic energy, a special group of insurance executives was organized with the cooperation and encouragement of the Atomic Energy Commission. The work begun last March covered a three-month study of a number of A.E.C. facilities with the viewpoint of developing information and criteria on the insurability of industrial installations and to make appropriate recommendations on any legislation that might be considered necessary. The group was to serve also as a liaison unit between the government and the commercial insurance market. Until this group was appointed, insurance companies had only limited knowledge of atomic power operations prior to the enactment of the A.E.C. Act of 1954; their subsidiaries had, however, initiated hazard survey studies more than five years ago on the shipment, storage, and handling of radioisotopes and on the design, installation, and protected operation of cyclotrons and particle accelerators.

Preliminary report issued

The preliminary interim report released last July submitted the following principal conclusions:

1. That the catastrophe potential, although being more serious than anything now known in industry, is remote in occurrence because of the progress made in developing controls to prevent a dangerous incident and engineering features to contain any released radioactivity in event of leakage or reactor failure.
2. That research and commercial reactors are insurable at commercial rates and that they might be considered in the category of the more hazardous types of chemical operations, and that physical damage to a reactor and its auxiliary equipment can be handled up to a prescribed limit in the same way as boiler and machinery coverage on extra-hazardous machinery now handled in other major industries.
3. That the most serious problem as to amount of insurance available lies in the "third-party liability" insurance, where the insurer might be faced with catastrophe potentials, facing claims of an extreme magnitude for property losses in the immediate surroundings, decontamination, and workmen's compensation losses from other plants and from public damage in the general area adjacent to atomic reactor sites.
4. That insurances covering "business-interruption" and "use-and-occupancy" present a special problem requiring further consideration, and that it is desirable to form eventually special pools of existing underwriting groups for handling direct coverage on the plants. It was concluded by the group of experts that an agreeable maximum limit of primary liability can be worked out, but as a matter of public policy it should be the government's decision and responsibility whether or not to create a special federal fund which would provide a means of insurance in excess of the capacity of the commercial market.

Limit ranges as high as $100,000,000 to $500,000,000 have been suggested by certain industrial interests. This high order of magnitude of potential financial risk, anticipated in the event of major atomic disaster, resulted as a reaction to the new provision of the revised Atomic Energy Act of 1954. This stipulates that as a condition of his license every licensee of special nuclear material is subject to the condition that he shall "hold the United States and the Commission harmless from any damage resulting from use or possession" of such material. The importance of properly resolving a situation of this size and nature is apparent.

Further study program needed

To promote the insurability of atomic enterprises, it is considered necessary that the activity of an overseeing technical body, such as the present Reactor Safeguards Committee of the A.E.C., should be continued and that the current interim safety standards for all licensees be rigidly maintained. Because of the need for a broader knowledge of the various problems involved in commercial utilization of nuclear power, it is believed also that a continuing study program between the A.E.C. and the insurance experts, at required scientific and engineering levels, will help to resolve the many varied and important problems on a more realistic basis, and thereby promote insurance confidence. So formalized an approach by the different interests should result in a more comprehensive study of all aspects of pile technology contributing to the major problems of industrial application, and should help rationalize the hazard and safety problems all the way from the technical deficiencies of engineering to the moral responsibility of management. This organized joint procedure should go a long way toward alleviating some of the frightening reactions which have resulted from a blank assessment of the danger potentials of nuclear reactors.

Author Mathew M. Braidech is research director, Fire Prevention and Engineering Standards Department, of the National Board of Fire Underwriters, New York. He is a native of Cleveland, O., and a graduate chemical engineer. From 1936 to 1945 he was professor of industrial chemistry, Case Institute of Technology, Cleveland, O. He has been a special investigator in many fire and explosion disasters including the Cleveland Clinic nitrocellulose film fire (1927), East Ohio gas disaster (1944), Texas City disaster (1947), Holland Tunnel chemical fire (1949), the South Amboy port explosion (1949), General Motors (Livonia) Hydramatic plant (1953) fire, and the Bennington aircraft carrier explosion (1954). He is also a technical consultant on various safety boards and committees.

Literally dozens of different types of reactors have been proposed as primary energy sources for atomic plants, all requiring multiplicity of controls and special safety mechanisms. Each type has different advantages and disadvantages, in the form of flexibility and variability of operation, accessibility, and repair of equipment, ease of inspection and maintenance, and automatic shutdown to avoid runaway reactor damage. As a result of endless research and constant testing during the past twelve years, twenty-five nuclear reactors have been safely operated for the A.E.C. without accident involving contamination of off-site property. Nevertheless, there remains the problem of converting such experimental reactors from research laboratories and government test facilities, where supervision and automatic instrumentation are provided, and adapting them to industrial installations, where the associated operating hazards are augmented and the problems of fuel handling and reprocessing, preventive maintenance, and waste disposal and recovery become important cost items and major economic realities.

Practical program defined

To apply a realistic safety program to commercial developments the following general matters should be considered: Site selection or location of the actual nuclear power plant and possible involvement of adjoining and distant industrial properties with dangerous exposure of the public at large. Consideration must be also given to such factors as meteorological conditions and the surrounding terrain, including the so-called Acts of God, such as lightning, floods, windstorms, and earthquakes; and falling aircraft. To reduce more of the technical uncertainties to risks, design and operating problems should be given the fullest safety appraisal as follows:

1. A proper layout of power plant and auxiliary equipment to reduce the cost and time of shutdown in the event of accidental leakage or release of radioactivity due to structural failure should be provided. Provision should be made for an outer gas-tight housing to surround the entire reactor plant, or a series of enclosing vessels around critical equipment to contain fission products and control the spread of contamination to near-by off-site properties as a last-ditch safeguard for any major unforeseen nuclear accident.

2. Suitable materials of construction for various reactor components capable of withstanding service conditions of elevated temperatures, thermal shock, and holding proper impact and fatigue strength under prolonged operations are necessary. These various materials, whether employed for internal structures, reactor control elements, or as coolants and special claddings to protect other materials need to be considered in the light of their damage stability toward extreme nuclear radiation and exposure to severe erosion and corrosion environment. Long- and short-term possibilities of dimensional changes and destructive deterioration should be fully considered.
3. Reactor-core design to terminate automatically a runaway potential before unit is in danger—by preventing power rising to high temperature levels in exceedingly short time and melting or vaporizing structural parts—must be considered.
4. Required safety controls must be appraised such as appropriate interlocks and automatic instrumentation, including ultrarapid emergency controls and positive fail-safe mechanisms to safeguard against dangerous potentials.
5. Safety consideration must be given to engineering operations involved in the safe recombining of hydrogen and oxygen resulting from dissociation of water in certain types of reactors, recovery of unspent fuel and unused raw material, and refabrication of fuel elements, and waste disposal—which promises to be a matter of importance to the efficiency and economical operation of nuclear power plants.
6. A rigidly scheduled inspection and maintenance program should be organized to guard against inadequate design and malfunctioning of the reactor and breakdown of its key auxiliary equipment.

Common sense appraisal

Most of the foregoing problems have been recognized for some time and ought to be fairly well understood. A more complete solution of them should be vigorously pressed and every conceivable precautionary measure and skilled technique should be employed as a safeguard to minimize the development of an unsafe condition. All areas of uncertainty should be constantly and thoroughly reviewed, and the hazard and safety control problems found in them be subjected to a realistic appraisal, employing both common sense and technical judgment. There should be a basic clearing-house agreement on what is important and what is not, and workable and acceptable safeguards provided accordingly. To insure completeness of evaluation, such studies should involve the minds of a variety of interests, and should include a consideration of the possible types of incidents and frequency of chance or annual probability of occurrence, including the potential simultaneous failure of other unrelated operations. This "hazard imagineering" and "safety accounting" program should include also the possible damage consequences, the number and duration of downtime periods, the value of the power loss, repair costs, and the necessary prevention and protection maintenance. It is encouraging to note that the design of nuclear power facilities and their operating procedures will continue to be subject to the inspection and approval of the A. E. C., and that each reactor proposal must presently be accompanied by a description of the "maximum credible accident" and the designed safeguards to prevent such an accident.

Failures of operation

In addition to the foregoing technological problems there is need to guard against operational failures due to inattention, misjudgment, and other forms of human failure. It is obvious that the operation of such critical equipment should be in the hands of responsible and technically competent people who are fully versed in proper start-up and shutdown procedures and know what action to take in the event of a major accidental event.

The Commission has under formalized consideration a proposed regulation establishing procedures for licensing of qualified operators of the various reactor facilities, featuring renewal, modification, and revocation of such licenses. To insure stringent enforcement of this regulation, violations would be punishable as crimes and subject to serious penalties of fines and imprisonment.

Along with the operation controls, there is a growing need for establishing design, installation, inspection, and maintenance criteria for all types of reactors. In the attempts to protect the public, many governmental agencies at state level and other outside technical bodies are drafting safety regulations. Various technical committees of different segments of the insurance business, fire casualty, and liability groups, have responded to some of the problems associated with radiation safety in the transportation of radioactive chemicals and in the operation of various atomic energy equipments, such as cyclotrons and other particle accelerators. Contacts with various interests indicate that currently there exists a temporary "regulatory maze," and that all concerned should be cautioned to "make haste slowly," and that the A.E.C. should provide more detailed safety stipulations than has been the case up to now. In addition to providing the usual technical surveillance, the Commission should undertake to codify, at an early date, the layout and design of nuclear reactors and associated steam-producing equipment, and the construction, installation, and maintenance of same. Due consideration must also be given to protective security of such plants against malicious acts and sabotage.

Emergency planning—a must

Accidents are possible, despite rules and regulations, and this planning program should therefore include the preparation of emergency procedures and disaster planning to cover any catastrophical event. Such advance organized preparedness will minimize the length of shutdown and operation-loss time.

The costliness of such an occurrence is indicated by an instance (covered by insurance) in July, 1951, in which an accidental spill of 50 mg. radioactive chemical caused severe contamination of personnel and physical facilities in an instrument manufacturer's laboratory. This involved a monetary loss of $230,000, with $90,000 chargeable to contents contamination and $140,000 to the use and occupancy loss. In this connection the significance of the release of 10,000 curies of nuclear fission products in 1,000,000 gal. water, and the 14-month shutdown for salvage and repair at the government-owned site of the Canadian Chalk River experimental plant in December, 1952, becomes particularly important from a potential use and occupancy and business interruption insurance loss.

The confidence that has been expressed in the atomic energy program by the electric utilities (to date) indicates that commercial nuclear power is becoming one of the most rapidly evolving and growing developments in the history of American industry. At present, six major electrical utilities have come up with plans (within a space of a year), calling for power plant installations totaling nearly 900,000 kw., with investment values of more than $250,000,000.

It is thought that much of the confusion that exists in this period of flux will vanish in time with constructive thinking. Industrialized atomic energy can then be properly evaluated for insurance risk, with adequate coverage against major accidents and catastrophes. Every branch of professional endeavor is duty bound to muster its skills and resources for the fullest exploitation of the unbounded energy of the atom. With proper collaboration of such human, financial, and technical talents, and the establishment of equity of responsibility among governmental, industrial, and insurance interests we can move forward and hasten the day when atomic power becomes a reality for improved public welfare, social stability, national security, and technical supremacy.

Presented at A.I.Ch.E. Lake Placid meeting.

SOLIDS-THROUGHPUT NUMBER DIAGRAM

Modification of Equation (11) to in-

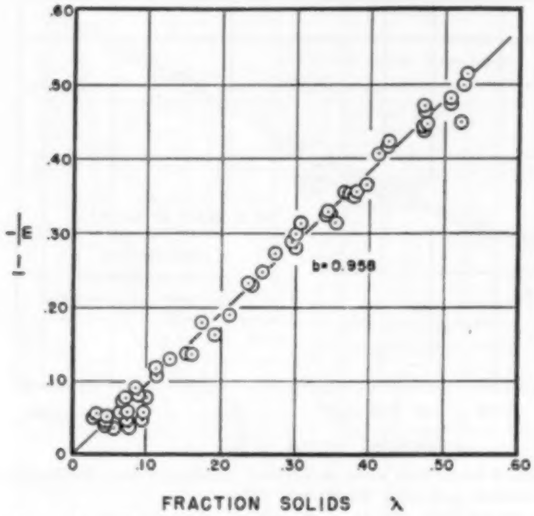


Fig. 8. Slope-function plot. Fuidization-sedimentation of No. 9 beads with water in 1.000-in. I.D. column.

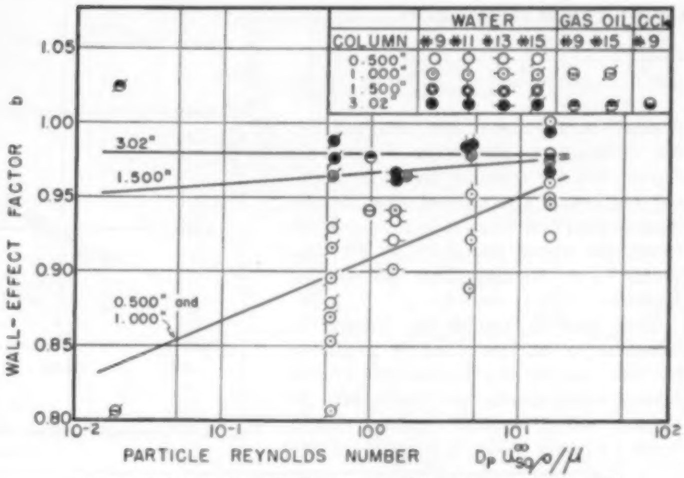


Fig. 9. Variation of wall-effect factor with column diameter and particle Reynolds number.

Thomas S. Mertes
and Harrison B. Rhodes

Sun Oil Company
Marcus Hook, Pennsylvania.

LIQUID-PARTICLE BEHAVIOR

Part 2

Actually, this latter effect was probably present. Within experimental precision it was too small to be firmly established, and had to be neglected. Precise data at much smaller values of D_t/D_p would be needed for satisfactory determination. Values of b could be readily established, mainly because fraction solids was not a critical variable in any single determination of m. As it was, the b's differed only moderately from unity and their effect was usually very small.

For concurrent operation, only a single point could be obtained at a given fraction solids. The second point needed to calculate m had to be found from a plot of zero-liquid or of fluidization data. For concurrent downflow of No. 9 beads in the 1.000-in. column, the slope-function plot was a straight 45° line passing slightly below the origin. This line was fitted by the expression, $m = 1/(1.03 - \lambda)$. The effect of this change was slight.

Data on concurrent upflow of No. 9 beads in the 1.000-in. column were also obtained. Duplicate solids rates varied up to 5% and prevented reliable determination of wall-effect factor. However, the value of b from countercurrent operation could be applied, and results were in general agreement with theory.

Table 5.—Over-all Average Values of Wall-Effect Factor for Countercurrent Operation

System	Reynolds Number, N_{Re}	Tube Diam. D_t, in.	Wall-Effect Factor, b
No. 9 beads in water	16	0.500	0.925
		1.000	0.958
		1.500	0.976
		3.02	0.985
No. 9 beads in CCl_4	16	3.02	0.980
No. 11 beads in water	4.8	1.000	0.938
		1.500	0.984
		3.02	0.986
No. 13 beads in water	1.45	0.500	0.930
		1.000	0.920
		1.500	0.959
		3.02	0.965
No. 9 beads in gas oil	0.98	1.000	0.943
		3.02	0.979
No. 15 beads in water	0.155	0.500	0.906
		1.000	0.875
		1.500	0.962
		3.02	0.982
No. 15 beads in gas oil	0.019	1.000	0.804
		3.02	1.025
Silica gel in water			
30–40 mesh	17	1.000	0.960
		3.02	0.991
60–80 mesh	3.9	1.000	0.940

Points for $\lambda < 0.15$ omitted in averaging.

SLIP-VELOCITY NUMBER

According to Equation (18) slip-velocity numbers should be independent of the type of operation. Therefore a comparison was made up of $u_{s\lambda}/u_{so}^{\infty}$ calculated from zero-liquid, countercurrent, and fluidization data over a wide range of fraction solids for the No. 9 beads in water in the 1.000-in. column. The value of b from Figure 9 was used. Results are shown on Figure 10 with $1 - u_{s\lambda}/u_{so}^{\infty}$ plotted against λ. This log-log plot is suggested by Equation (*7*). Data for the different operations fall on a single line.

PARTICLE-VELOCITY NUMBER DIAGRAM

The particle-velocity number diagram for No. 9 beads in water in the 1.000-in. column, Figure 11, was drawn with the use of slip-velocity numbers from the line on Figure 10. Lines are drawn for constant values of fraction solids. The concurrent-upward (lift) data for the same system are shown in Figure 12.

Part I of this article appeared in the September issue, page 429.

SOLIDS-THROUGHPUT NUMBER DIAGRAM

Modification of Equation (11) to include the effect of walls gives

$$\frac{G}{u_{so}^{\infty}} = \lambda\left[\frac{u_{s\lambda}}{u_{so}^{\infty}} + \frac{1}{1-b\lambda}\frac{L}{u_{so}^{\infty}}\right] \tag{19}$$

A solids-throughput number diagram for No. 9 beads is shown in Figure 13. Curves are for constant liquid-throughput numbers. The dashed line for the loose-settled bed fraction solids of 0.585 forms the upper boundary of the diagram. The flooding line defined by Equation (12) is shown.

This plot is similar to Figure 1. However, a narrow zone is predicted in the concurrent-downward region where liquid-throughput lines are *S*-shaped and a second *P*-phase should occur. Larger zones are predicted for systems having smaller values of slip-velocity number. Slip-velocity numbers from Equation (7) are large enough that *S*-shaped curves are not predicted.

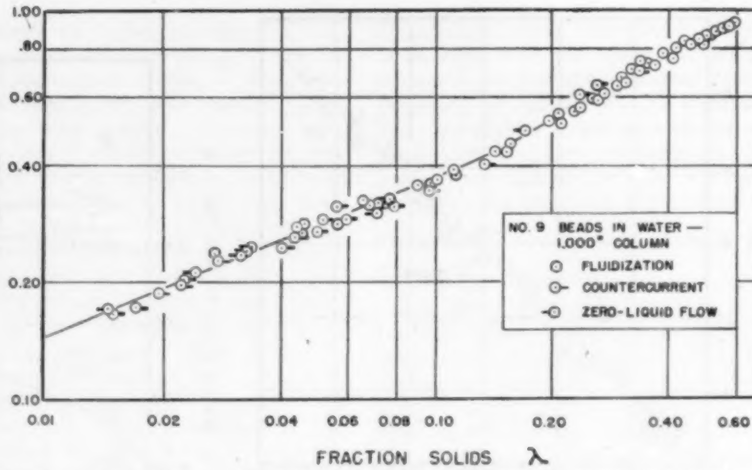
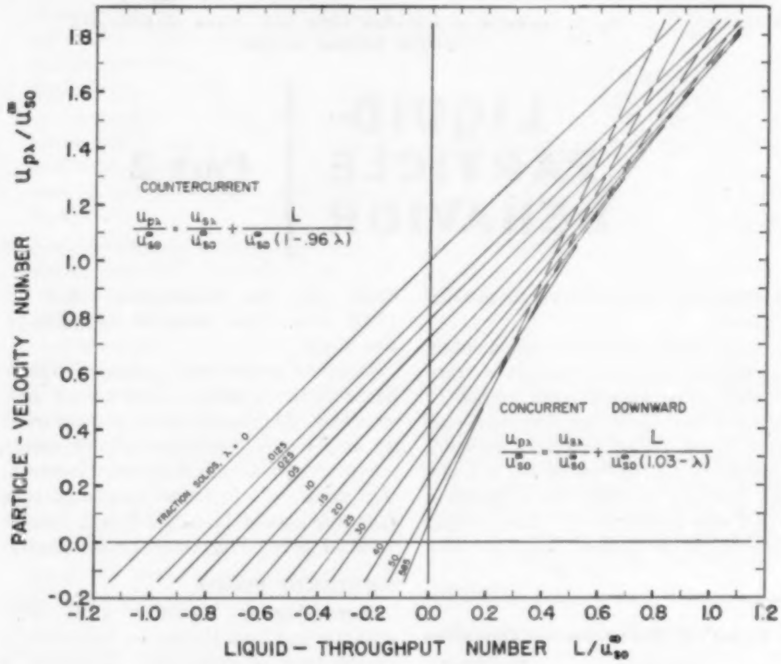
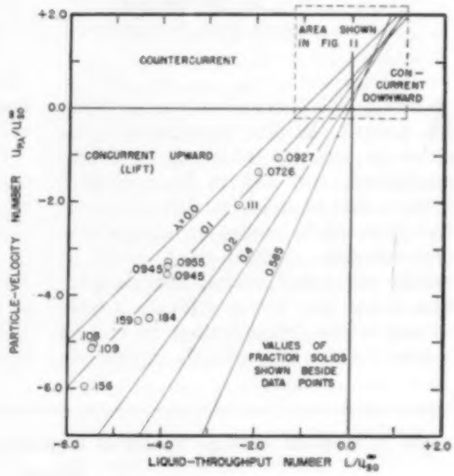


Fig. 10. Slip-velocity numbers for No. 9 beads with water in 1.000-in. I.D. column from fluidization, countercurrent, and zero liquid flow data.



◄ Fig. 11. Particle-velocity number diagram for No. 9 beads with water in 1.000-in. I.D. column.

Fig. 12. Small-scale particle-velocity number diagram showing concurrent upflow data for No. 9 beads with water in 1.000-in. I.D. column.



VARIATION OF SLIP-VELOCITY NUMBER RELATIONS

Relations between slip-velocity number and fraction solids for the several systems in 1.000-in. and 3.02-in. columns are shown in Figures 14 and 15. The particle Reynolds number, $D_p u_{so}^{\infty} \rho/\mu$, is given for each curve. Data for the 0.500-in. and 1.500-in. columns showed no significant differences. It was concluded that the difference between $u_{s\lambda}/u_{so}^{\infty}$ and $u_{s\lambda}^{\infty}/u_{so}^{\infty}$ for all the data was less than the experimental uncertainty.

Literature data used to extend the range of systems include: sedimentation data of Steinour (*16*) for 13.57-μ glass beads, countercurrent data of Elgin and Foust (*6*) for 0.127-in. Socony-Vacuum catalyst beads, and fluidization data of Wilhelm and

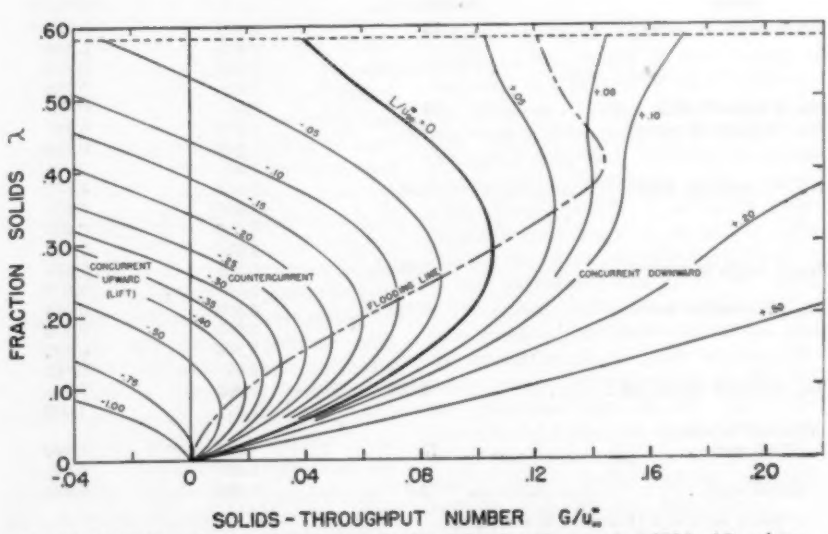


Fig. 13. Solids-throughput number diagram for No. 9 beads with water in 1.000-in. I.D. column.

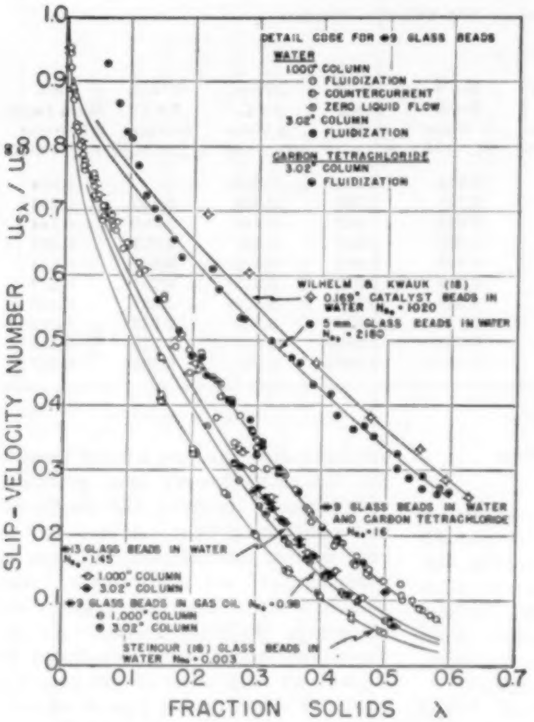


Fig. 14. Comparison of slip-velocity number curves for various systems.

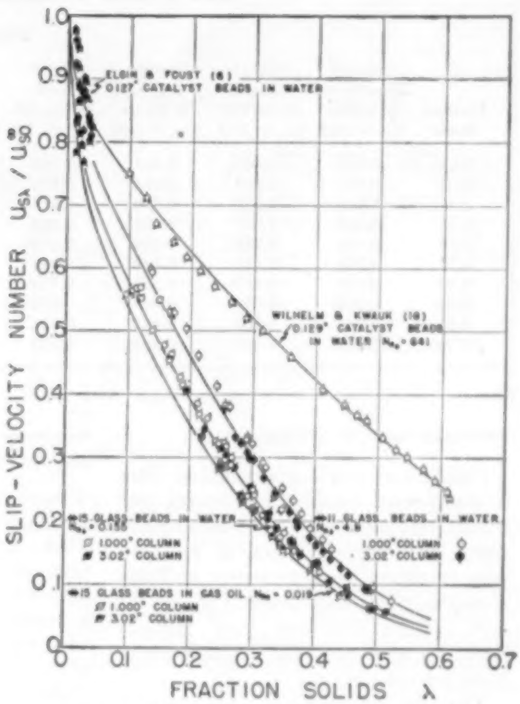


Fig. 15. Comparison of slip-velocity number curves for various systems.

Kwauk (*18*) for 0.5-cm. glass beads and two sizes of catalyst beads. In calculating slip-velocity numbers from these data, *b* was assumed unity.

For extending curves of slip-velocity number to low fraction solids, data were plotted as in Figure 10. Lines through the points closely paralleled the one for No. 9 beads which extended below $\lambda = 0.003$. They were therefore extrapolated parallel and the results were transferred to Figures 14 and 15.

Attempts to find empirical equations for slip-velocity number were abandoned when it was apparent that results would be too cumbersome to be useful. The graphical presentation is simplest and most convenient at present.

EFFECT OF PARTICLE REYNOLDS NUMBER

On Figures 14 and 15 the slip-velocity numbers decrease with particle Reynolds number. Figure 16 shows this trend more clearly, slip-velocity numbers being plotted against particle Reynolds number. The crossplot values used are given in Table 6. Points calculated from Equation (8) were assumed to be the upper limit.

Slip-velocity numbers vary smoothly with particle Reynolds number although there is a rapid transition beginning around 10. In order to vary Reynolds number at constant particle diameter, No. 9 beads were run in both water and gas oil. Data were also obtained for

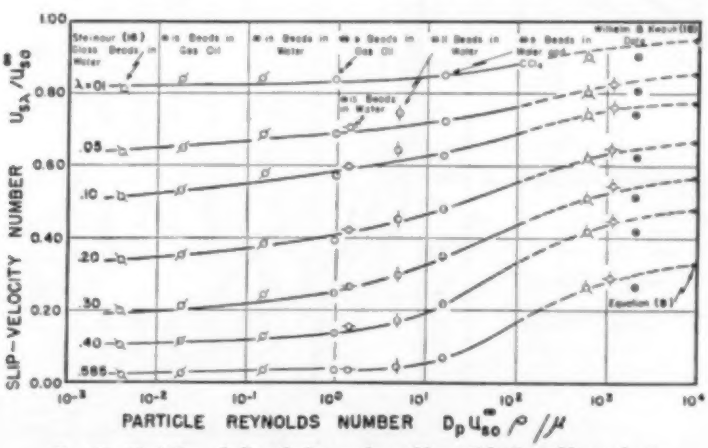


Fig. 16. Variation of slip-velocity number with particle Reynolds number. Lines of constant fraction solids.

fluidization

No. 15 beads in both water and gas oil and for No. 9 beads in carbon tetrachloride.

General Correlation and Calculation Methods

Slip-velocity numbers in Table 6 can be used to draw a large-scale plot of Figure 16 for reading off values for a given system. These numbers used with Equation (18) or (19) and Figure 9 will give a complete description of system behavior. This is a general correlation for countercurrent flow of uniformly sized, spherical particles in liquids. It covers the particle Reynolds number range of 0.001 to 10,000. For concurrent operation, either upward or downward, the results would be essentially correct even if the same values of *b* were used. Particle-velocity number and solids-throughput number diagrams can be constructed.

A detailed error analysis showed 95% confidence limits on slip-velocity number were less than ±5 to ±8% for Reynolds numbers between 0.001 and 20. Uncertainties in u_{s0}^{∞} and *b* are included. For Reynolds numbers between 20 and 10,000 confidence limits are estimated to be ±15 to ±20%. The 95% confidence limits are about twice the standard deviation.

SOLIDS-THROUGHPUT NUMBER DIAGRAM

Modification of Equation (11) to include the effect of walls gives

$$\frac{G}{u_{so}^{\infty}} = \lambda\left[\frac{u_{s\lambda}}{u_{so}^{\infty}} + \frac{1}{1-b\lambda}\,\frac{L}{u_{so}^{\infty}}\right] \quad (19)$$

A solids-throughput number diagram for No. 9 beads is shown in Figure 13. Curves are for constant liquid-throughput numbers. The dashed line for the loose-settled bed fraction solids of 0.585 forms the upper boundary of the diagram. The flooding line defined by Equation (12) is shown.

This plot is similar to Figure 1. However, a narrow zone is predicted in the concurrent-downward region where liquid-throughput lines are S-shaped and a second P-phase should occur. Larger zones are predicted for systems having smaller values of slip-velocity number. Slip-velocity numbers from Equation (7) are large enough that S-shaped curves are not predicted.

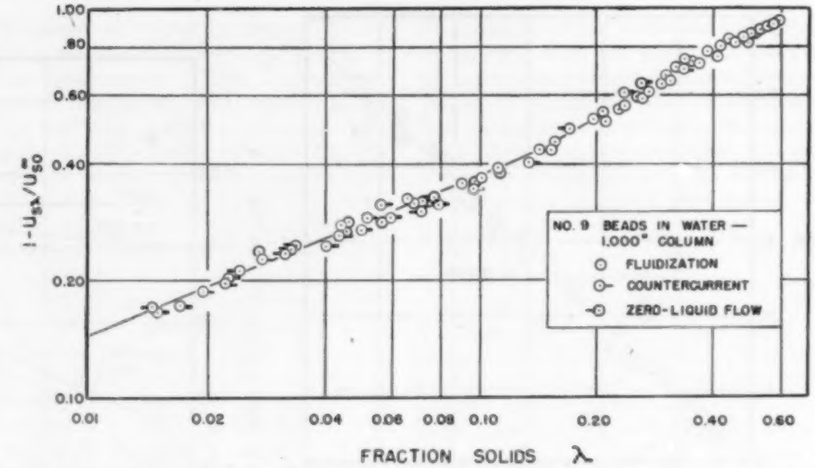
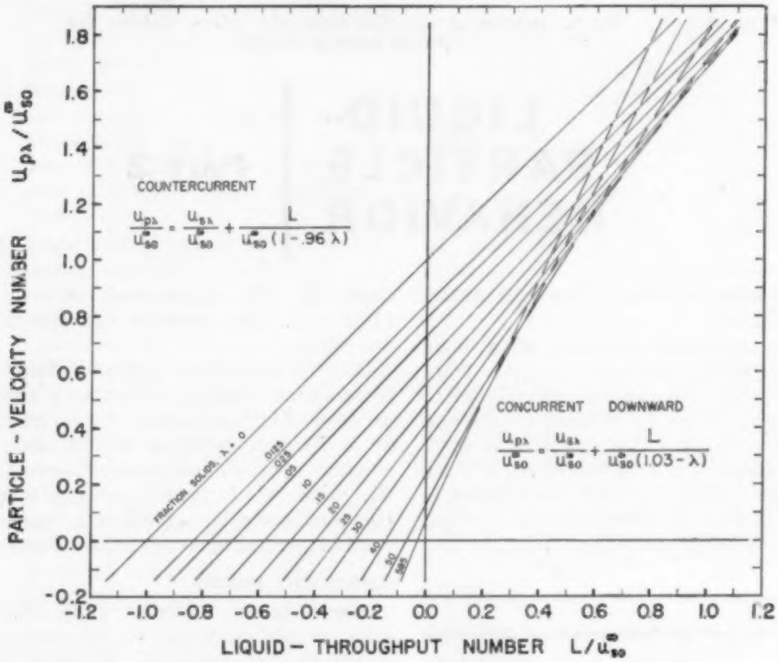
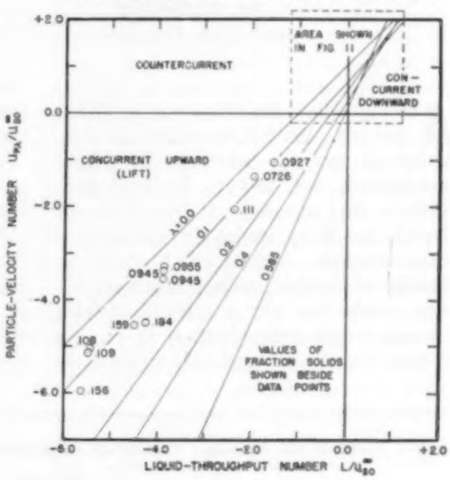


Fig. 10. Slip-velocity numbers for No. 9 beads with water in 1.000-in. I.D. column from fluidization, countercurrent, and zero liquid flow data.



◄ Fig. 11. Particle-velocity number diagram for No. 9 beads with water in 1.000-in. I.D. column.

Fig. 12. Small-scale particle-velocity number diagram showing concurrent upflow data for No. 9 beads with water in 1.000-in. I.D. column.



VARIATION OF SLIP-VELOCITY NUMBER RELATIONS

Relations between slip-velocity number and fraction solids for the several systems in 1.000-in. and 3.02-in. columns are shown in Figures 14 and 15. The particle Reynolds number, $D_p u_{so}^{\infty}\rho/\mu$, is given for each curve. Data for the 0.500-in. and 1.500-in. columns showed no significant differences. It was concluded that the difference between $u_{s\lambda}/u_{so}^{\infty}$ and $u_{s\lambda}^{\infty}/u_{so}^{\infty}$ for all the data was less than the experimental uncertainty.

Literature data used to extend the range of systems include: sedimentation data of Steinour (*16*) for 13.57-μ glass beads, countercurrent data of Elgin and Foust (*6*) for 0.127-in. Socony-Vacuum catalyst beads, and fluidization data of Wilhelm and

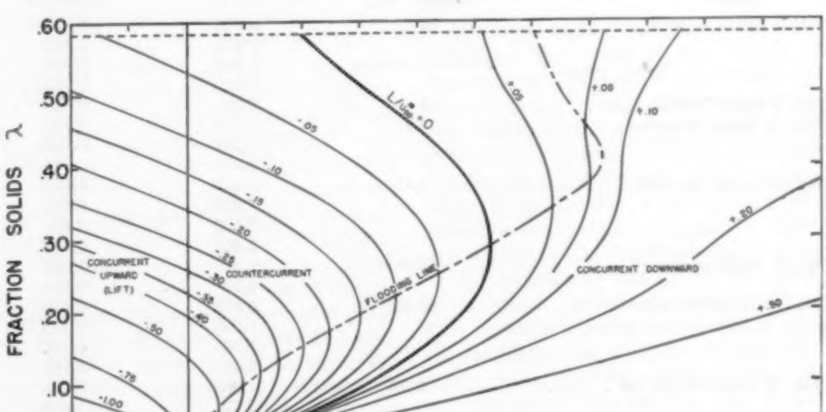


Fig. 13. Solids-throughput number diagram for No. 9 beads with water in 1.000-in. I.D. column.

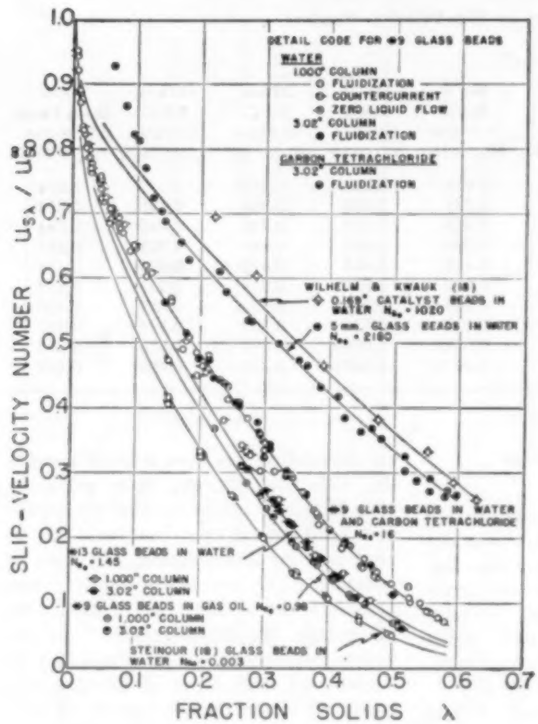


Fig. 14. Comparison of slip-velocity number curves for various systems.

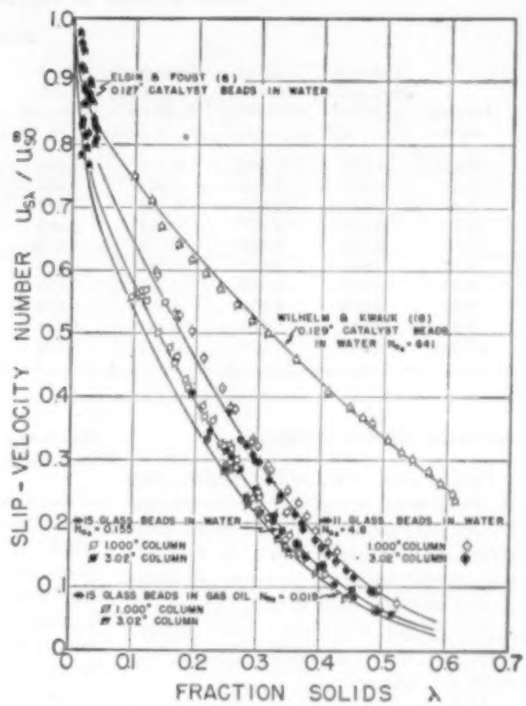


Fig. 15. Comparison of slip-velocity number curves for various systems.

Kwauk (*18*) for 0.5-cm. glass beads and two sizes of catalyst beads. In calculating slip-velocity numbers from these data, b was assumed unity.

For extending curves of slip-velocity number to low fraction solids, data were plotted as in Figure 10. Lines through the points closely paralleled the one for No. 9 beads which extended below $\lambda = 0.003$. They were therefore extrapolated parallel and the results were transferred to Figures 14 and 15.

Attempts to find empirical equations for slip-velocity number were abandoned when it was apparent that results would be too cumbersome to be useful. The graphical presentation is simplest and most convenient at present.

EFFECT OF PARTICLE REYNOLDS NUMBER

On Figures 14 and 15 the slip-velocity numbers decrease with particle Reynolds number. Figure 16 shows this trend more clearly, slip-velocity numbers being plotted against particle Reynolds number. The crossplot values used are given in Table 6. Points calculated from Equation (8) were assumed to be the upper limit.

Slip-velocity numbers vary smoothly with particle Reynolds number although there is a rapid transition beginning around 10. In order to vary Reynolds number at constant particle diameter, No. 9 beads were run in both water and gas oil. Data were also obtained for No. 15 beads in both water and gas oil and for No. 9 beads in carbon tetrachloride.

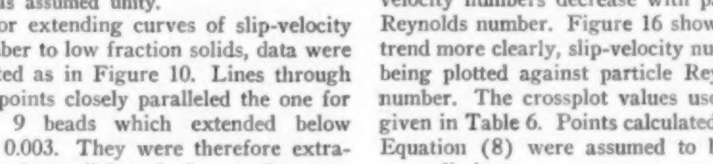


Fig. 16. Variation of slip-velocity number with particle Reynolds number. Lines of constant fraction solids.

General Correlation and Calculation Methods

Slip-velocity numbers in Table 6 can be used to draw a large-scale plot of Figure 16 for reading off values for a given system. These numbers used with Equation (18) or (19) and Figure 9 will give a complete description of system behavior. This is a general correlation for countercurrent flow of uniformly sized, spherical particles in liquids. It covers the particle Reynolds number range of 0.001 to 10,000. For concurrent operation, either upward or downward, the results would be essentially correct even if the same values of b were used. Particle-velocity number and solids-throughput number diagrams can be constructed.

A detailed error analysis showed 95% confidence limits on slip-velocity number were less than ±5 to ±8% for Reynolds numbers between 0.001 and 20. Uncertainties in u_{so}^{∞} and b are included. For Reynolds numbers between 20 and 10,000 confidence limits are estimated to be ±15 to ±20%. The 95% confidence limits are about twice the standard deviation.

Table 6.—Effect of Particle Reynolds Number on Slip-Velocity Number

Fraction Solids	Steinour Glass Beads in Water $N_{Re} = .003$	No. 15 Beads in Gas Oil $N_{Re} = .019$	Beads No. 15 in Water $N_{Re} = .155$	No. 9 Beads in Gas Oil $N_{Re} = .98$	No. 13 Beads in Water $N_{Re} = 1.45$	No. 11 Beads in Water $N_{Re} = 4.8$	No. 9 Beads in Water $N_{Re} = 16$	No. 9 Beads in CCl_4 $N_{Re} = 16$	.129-in. S.V.C. in Water $N_{Re} = 641$	.174-in. S.V.C. in Water $N_{Re} = 1020$	5-mm. Glass Beads in Water $N_{Re} = 2180$
	Slip-Velocity Number, $u_s\lambda/u_{so}^\infty$										
0.01	0.819	0.840	0.845	0.840	.....	.....	0.854	0.854	0.904	.....	0.904
0.05	0.640	0.652	0.683	0.690	0.706	0.745	0.725	0.725	0.809	0.830	0.808
0.10	0.518	0.537	0.580	0.577	0.600	0.643	0.635	0.635	0.742	0.765	0.744
0.15	0.425	0.437	0.462	0.480	0.507	0.548	0.556	0.556	0.681	0.708	0.682
0.20	0.340	0.353	0.394	0.398	0.424	0.458	0.485	0.485	0.623	0.655	0.624
0.30	0.200	0.212	0.242	0.250	0.272	0.300	0.350	0.350	0.519	0.551	0.519
0.40	0.105	0.115	0.130	0.139	0.156	0.174	0.220	0.220	0.420	0.452	0.423
0.50	0.050	0.054	0.064	0.070	0.081	0.088	0.125	0.125	0.335	0.365	0.335
0.55	0.030	0.034	0.042	0.046	0.054	0.065	0.0881	0.0881	0.295	0.323	0.295
0.585	0.022	0.025	0.032	0.034	0.039	0.046	0.0673	0.0673	0.267	0.295	0.267

IRREGULAR-PARTICLE SYSTEMS

Fluidization and sedimentation data in water were obtained for sharply elutriated cuts from 30-40 and 60-80 mesh silica gel. Particle Reynolds numbers were calculated from diameters in Table 2 and average experimental values of u_{so}^∞. Slope functions gave straight lines; b's were not much different from those for spheres.

The log-log plot of $1 - u_{s\lambda}/u_{so}^\infty$ against fraction solids gave straight lines (Figure 17) which had steeper slopes than for spheres. Points were also calculated from fluidization data of Wilhelm and Kwauk (*18*) for sea sand and crushed rock with the use of b equal to 0.983. Lines through these points have comparable slopes but they fall much lower.

The behavior of an irregular-particle system can be readily determined from a small amount of fluidization-sedimentation data. The value of b and the variation of slip velocity can be found from these data. A dimensional solids-throughput diagram can then be constructed without knowledge of D_p or u_{so}^∞.

Maximum Throughputs (Flooding) and Holdup

A relationship between maximum throughputs and fraction solids was desired. A solids throughput number diagram for each of several Reynolds numbers was therefore constructed. To have a common basis, the wall-effect factor was taken equal to 1.0. Flooding conditions were read from each diagram.

Results are given in Table 7 and shown in Figure 18. Maximum liquid-throughput numbers, $(L/u_{so}^\infty)_{max.}$, are plotted against maximum solids-throughput numbers, $(G/u_{so}^\infty)_{max.}$, to give lines of constant particle Reynolds number. The subscript distinguishes the maximum values from other values calculated from Equation (19). The lines of constant fraction solids were developed from separate plots of fraction solids against liquid-throughput number at each Reynolds number. These values are given in Table 8.

Any arrangement of the four variables, λ, $(G/u_{so}^\infty)_{max.}$, $(L/u_{so}^\infty)_{max.}$, and N_{Re} could be used on one chart or a combination of two charts. The present correlation has been selected because the behavior changes only gradually with Reynolds number. Also the liquid- and solids-throughput numbers can be read without interpolation, and lines of constant L/G are easily added. Any consistent set of units can be used since all groups are dimensionless. As the basic correlations were established in regions on both sides of flooding, the predicted values do not depend on arbitrary or visual definitions of flooding point. When either throughput rate is set, the 95% confidence limits for the other rate are ±10% for Reynolds numbers from 0.001 to 100. Limits of ±20% are estimated for the range 100 to 10,000.

Near maximum throughput small changes in solids rates produce large changes in fraction solids. For this reason 0.90-0.95 of maximum throughput may be an upper limit for stable operation and column area should be increased accordingly. At 0.90 of maximum, fraction solids will decrease about 20% from the flooding value for P-phase operation or increase 20% for N-phase operation.

Flooding data on solid-liquid and on

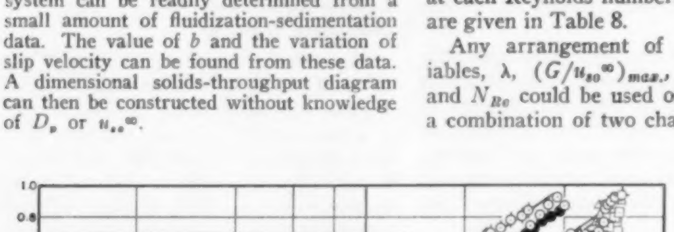


Fig. 17. Slip-velocity numbers for irregular particles in water. Calculated from fluidization data.

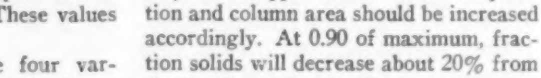


Fig. 18. Generalized flooding correlation.

Table 7.—Variation of Flooding Conditions with Particle Reynolds Number

N_{Re}	0.01		0.1		1		10		100		1000		10,000	
$(L/u_{so}^{\infty})_{max.}$	λ	$(G/u_{so}^{\infty})_{max.}$	λ	$(G/u_{so}^{\infty})_{max.}$	λ	$(G/u_{so}^{\infty})_{max.}$	λ	$(G/u_{so}^{\infty})_{max.}$	λ	$(G/u_{so}^{\infty})_{max.}$	λ	$(G/u_{so}^{\infty})_{max.}$	λ	$(G/u_{so}^{\infty})_{max.}$
0.00	0.209	0.0708	0.219	0.0749	0.232	0.0830	0.270	0.0990	0.360	0.1350	0.461	0.1760	0.490	0.200
0.10	0.159	0.0480	0.164	0.0514	0.180	0.0573	0.210	0.0689	0.261	0.0945	0.319	0.1165	0.350	0.131
0.20	0.113	0.0319	0.121	0.0349	0.134	0.0392	0.159	0.0470	0.200	0.0614	0.235	0.0785	0.259	0.087
0.30	0.086	0.0200	0.093	0.0224	0.105	0.0258	0.128	0.0304	0.159	0.0413	0.186	0.0520	0.209	0.057
0.50	0.044	0.0062	0.047	0.0068	0.052	0.0079	0.064	0.0100	0.084	0.0150	0.100	0.0191	0.115	0.021
1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0

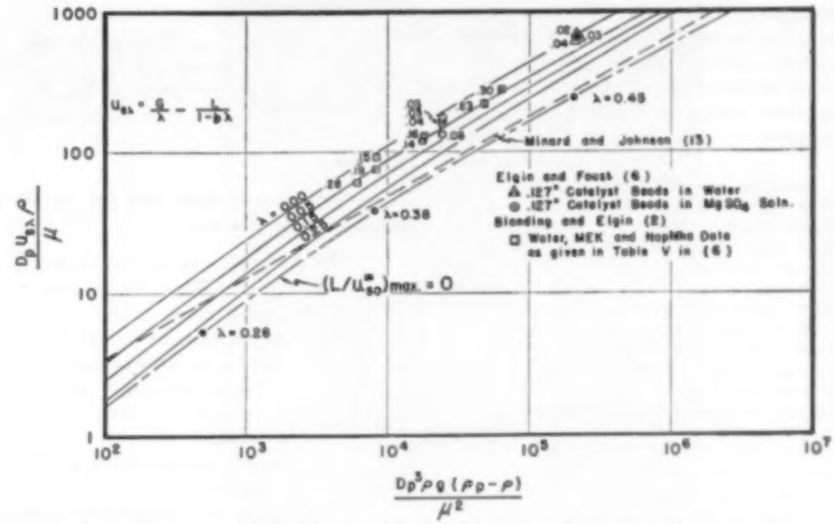


Fig. 19. Comparison of literature data with flooding correlation. Values of fraction solids or fraction holdup shown beside data points.

liquid-liquid systems for comparison with this correlation is limited. The work of Minard and Johnson (*13*) covers a variety of liquid-liquid systems. Lack of information prevents direct comparison of their results with Figure 18, which was therefore transposed to the form used by those authors shown in Figure 19.

On this plot the dimensionless group $D_p^3 \rho g(\rho_p - \rho)/\mu^2$ is equal to $3/4\ C N_{Re}^2$. This group is constant for a given fluid-particle system and is independent of operating conditions. The other group, $D_p u_{s\lambda} \rho/\mu$, equals $(N_{Re})(u_{s\lambda}/u_{so}^{\infty})$. Its value can be calculated from Figure 16. However the three parameters, λ, $(G/u_{so}^{\infty})_{max.}$, and $(L/u_{so}^{\infty})_{max.}$, must be included for Figure 19 to be as useful as Figure 18. Since Figure 19 is provided merely for comparing data, only lines of constant fraction solids and $(L/u_{so}^{\infty})_{max.} = 0$ are shown. On this latter line the value of λ is given at three points.

Minard and Johnson (*13*) defined slip velocity at flooding by

$$u_{s\lambda} = \frac{G}{\lambda} - \frac{L}{1-\lambda} \qquad (20)$$

This equation differs from the dimensional form of Equation (19) only by sign convention and the absence of wall-effect factor. However, Minard and Johnson were apparently unaware

fluidization

of its general significance. Actually, this equation defines slip velocity not just at flooding but for all other conditions. When flooding data are plotted on Figure 19, the original throughputs and fraction holdups cannot be recovered without the additional parameters. Minard and Johnson used the single dashed line to represent their data.

The flooding points shown are data of Blanding and Elgin (*2*) for liquid-liquid systems and Elgin and Foust (*24*) for solid-liquid systems. Values of fraction

Table 8.—Crossplot Values for Lines of Constant Fraction Solids at Flooding

	Values of $(L/u_{so}^{\infty})_{max.}$						
N_{Re}	0.01	0.1	1	10	100	1000	10,000
0.05	0.467	0.487	0.514	.....	.....	.....	.....
0.10	0.241	0.270	0.308	0.357	0.456	0.500	.....
0.15	0.120	0.130	0.163	0.218	0.318	0.380	0.424
0.20	0.018	0.034	0.060	0.115	0.200	0.268	0.316
0.25	.....	.....	.....	0.028	0.116	0.178	0.217
0.30	.....	.....	.....	.....	0.051	0.118	0.147
0.35	.....	.....	.....	.....	0.007	0.074	0.100
0.40	.....	.....	.....	.....	.....	0.038	0.060
0.45	.....	.....	.....	.....	.....	0.010	0.026

holdup are shown beside the points. Lack of closer agreement arises from experimental problems and the various definitions of flooding. The present theory provides means to examine closely this situation.

Blanding and Elgin described unmistakably the formation of the *N*-phase in liquid-liquid systems. As flooding conditions were approached, a phase of definitely higher fraction holdup (*N*-phase) was observed to form at the end of the column where discontinuous phase was withdrawn. This *N*-phase then continued to accumulate back to the column entrance. Flooding was defined as the condition where the interface between the *P*-phase and the *N*-phase could be held within the tapered entrance section. At this point the *N*-phase was in equilibrium with the *P*-phase, which had a lower fraction holdup.

Such operation requires a restriction on the flow of the discontinuous phase from the column exit. At maximum throughput there would be no difference between the holdup in these two phases. Hence, the wide differences described by Blanding and Elgin indicate that the reported flooding throughputs were approximately 70-90% of maximum. The fraction holdups were measured in the more dense *N*-phase and are therefore too high, as indicated on Figure 19.

Elgin and Foust defined flooding as the condition where particles were rejected from the column entrance. They also described stable operation with a dense bed of solids in the conical solids-entrance section. Their curves of holdup vs. solids rate indicate that rejection occurred at about 90-95% of maximum throughput. These facts suggest that a slight flow restriction existed between the entrance section and the column. Their flooding points nevertheless plot close to prediction.

Minard and Johnson defined flooding as the condition where a high concentration of drops accumulated in the entrance cone finally overflowed. Their observations indicate that fraction holdup in the approach section was as high or higher than in the column. This points to the existence of *N*-phase in the approach section. It is estimated that the reported flooding throughputs were about 95% of maximum. Their actual data points would scatter around the dashed line and fall within the region bounded by the predicted lines. Individual points cannot be identified. Because of a pump limitation on liquid throughput it appears that only high holdups could be investigated for systems with high Reynolds numbers. At lower Reynolds numbers a wider range of holdups could be studied. The lumping of data, regardless of the holdup, causes their line to cut diagonally from the center of the region of possible operation at low Reynolds numbers, to the region of high holdups at high Reynolds numbers.

Despite these problems the data of Minard and Johnson (*13*) and Blanding and Elgin (*2*) indicate that Figure 18—from which Figure 19 was developed—can be applied to liquid-liquid systems. However, their observations as well as those of Elgin and Foust (*6*) indicate that entrance and exit design prevent attainment of maximum throughputs. The values predicted from Figure 18 are real rather than hypothetical limits. They should be obtained if problems of end-design can be overcome.

Acknowledgment

The authors wish to acknowledge the assistance of G. R. Stroup and K. A. Van Wormer, Jr., in the collection of the experimental data.

Notation

The c.g.s. system is shown but any set of consistent units may be used.

b = wall-effect factor, dimensionless
C = drag coefficient, dimensionless
D_p = particle diameter, cm.
D_t = tube or column diameter, cm.
G = solids or discontinuous-phase volumetric throughput per unit cross-sectional area, cc./sq. cm.)(sec.)
g = local acceleration due to gravity, (cm./sec.)/sec.
G/u_{so}^{∞} = solids or discontinuous-phase throughput number, dimensionless
L = liquid or continuous - phase throughput per unit cross-sectional area, cc./(sq.cm.)(sec.)
L/u_{so}^{∞} = liquid or continuous - phase throughput number, dimensionless
m = slope of particle-velocity number line at constant fraction solids, dimensionless
N_i = number of particles of diameter $(D_p)_i$
N_{Re} = particle Reynolds number $D_p u_{so}^{\infty} \rho/\mu$, dimensionless
P = probability level
u_{Lo}^{∞} = liquid velocity in a single-particle infinite system, cm./sec.; equal to L
$u_{L\lambda}^{\infty}$ = average liquid velocity in a multiparticle infinite system, cm./sec.; approaches L as $\lambda \rightarrow 0$
u_{po} = particle velocity for a single particle in a system limited by vertical walls, cm./sec.
u_{po}^{∞} = particle velocity for a single particle in an infinite system, cm./sec.
$u_{p\lambda}$ = particle velocity in a multiparticle system limited by vertical walls, cm./sec.
$u_{p\lambda}^{\infty}$ = particle velocity in a multiparticle infinite system, cm./sec.
$u_{p\lambda}^{\infty}/u_{so}^{\infty}$ = particle - velocity number for solids or discontinuous phase, dimensionless
u_{so} = slip velocity for a single particle in a system limited by vertical walls, cm./sec.
u_{so}^{∞} = slip velocity for a single particle in an infinite system, cm./sec.
$(u_{so}^{\infty})_i$ = slip velocity of particles of diameter $(D_p)_i$, cm./sec.
$u_{s\lambda}$ = slip velocity in a multiparticle system limited by vertical walls, cm./sec.
$u_{s\lambda}^{\infty}$ = slip velocity in a multiparticle infinite system, cm./sec.
$u_{s\lambda}/u_{so}^{\infty}$,
$u_{s\lambda}^{\infty}/u_{so}^{\infty}$ = slip - velocity numbers for solids or discontinuous phase, dimensionless
λ = volume fraction solids or discontinuous phase, dimensionless
μ = liquid viscosity, poises
ρ = liquid density, g./cc.
ρ_p = particle density, g./cc.

Subscripts

l.s. = loose-settled bed
max. = condition of maximum throughput
o = single particle
p = particle
s = slip
λ = multiparticle system

Superscript

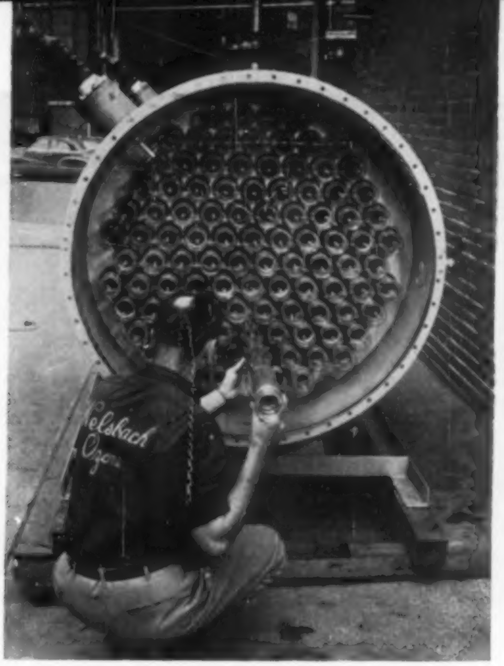
∞ = infinite-fluid system

Literature Cited

1. Bacon, L. G., *J. Frank. Inst.*, **221**, 251 (1936).
2. Blanding, F. H., and J. C. Elgin, *Trans. Am. Inst. Chem. Engrs.*, **38**, 305 (1942).
3. Brinkman, H. C., *Applied Sci. Research*, **A1**, 27 (1947).
4. Burgers, J. M., *Proc. Nederland. Akad. Wetenschap.*, **44**, 1045, 1177 (1941); **45**, 9, 126 (1942).
5. Carman, P. C., *Trans. Inst. Chem. Engrs. (London)*, **15**, 152 (1937).
6. Elgin, J. C., and H. C. Foust, *Ind. Eng. Chem.*, **42**, 1127 (1950).
7. Faxen, H., *Arkiv Mat. Astron. Fysik*, **17**. No. 27, 1 (1922).
8. Hancock, R. T., *Mining Mag.*, **67**, 179 (1942).
9. Johnson, E., *Inst. Gas Engrs.*, Commun. No. 378/179 (1951).
10. Leva, M., M. Weintraub, M. Grummer, M. Pollchik, and H. H. Storch, *U. S. Bur. Mines Bull.* **504** (1951).
11. Lewis, W. K., E. R. Gilliland, and W. C. Bauer, *Ind. Eng. Chem.*, **41**, 1104 (1949).
12. Matheson, G. L., *Ind. Eng. Chem., Anal. Ed.*, **24**, 904 (1952).
13. Minard, G. W., and A. I. Johnson, *Chem. Eng. Progress*, **48**, 62 (1952).
14. Morse, R. D., *Ind. Eng. Chem.*, **41**, 1117 (1949).
15. Newton, I., "Mathematical Principles of Natural Philosophy and His System of the World." Trans. by A. Motte, rev. by F. Cajori, Univ. of Calif. Press., p. 353 (1934).
16. Steinour, H. P., *Ind. Eng. Chem.*, **36**, 618 (1944).
17. Verschoor, H., *Applied Sci. Research*, **A2**, 155 (1951).
18. Wilhelm, R. H., and M. Kwauk, *Chem. Eng. Progress*, **44**, 201 (1948).
19. Zenz, F. A., *Ind. Eng. Chem.*, **41**, 2801 (1949).

Presented at A.I.Ch.E. Toronto meeting.

(The End)



Closeup view of the Welsbach G-204 ozonator, such as those installed at Emery and other large ozone plants.

ENGINEERING PROBLEMS IN THE UTILIZATION OF tonnage ozone

Victor A. Hann

The Welsbach Corporation, Philadelphia, Pennsylvania

A general but erroneous impression has lingered on concerning the explosiveness of ozonized oxygen. This paper reports on what engineers at a firm specializing in this field have done to eliminate this danger with equipment based on original aviation developments.

First what is industrial ozone? It is an unstable gas considerably diluted with air or oxygen. From a practical standpoint, it is uneconomical or hazardous to concentrate, ship, and store; it should be produced and used as needed. The most economical means of producing ozone in quantity is by passing air or oxygen through a high voltage electrical discharge in a machine called an ozonator. Ozone can be generated from air or from oxygen. However, most ozonators will yield much more ozone when fed with oxygen.

Within limits the concentration of ozone (normally 1 or 2%) can be increased by simply reducing the gas flow through the ozonator; unfortunately, this is accomplished at the cost of a loss in over-all production. The higher one tries to make the ozone concentration, the less ozone one gets per hour from the ozonator. Ozone concentrations of 5% (in air) or 10% (in oxygen) are possible but usually are uneconomical. The yield drops to zero slightly above these limits. The explanation is that the electric discharge not only produces ozone

$$3\ O_2 \rightarrow 2\ O_3$$

but also can destroy it

$$2\ O_3 \rightarrow 3\ O_2$$

the velocity of the reverse reaction increasing with the ozone concentration.

In the following discussion all references to ozone mean commercial ozone, i.e., air or oxygen containing ozone concentrations of 10% or less.

Ozone has long been used in the laboratory for structural analysis. It readily and specifically adds to carbon-carbon double bonds, forming ozonides which can be decomposed, cleaving the structure at the original position of the double bond and permitting its location by identification of the reaction products. In addition to this ozonization reaction (a and b, Table 1), ozone acts as a powerful general oxidant in both inorganic and organic reactions and in some cases acts as a catalyst for the reactions of molecular oxygen. A number of typical ozone reactions are shown in Table 1.

Early attempts at commercial utilization of ozone met with indifferent success because of the absence of reliable, efficient, and reasonably priced ozone equipment.

About 15 years ago, Welsbach started a program for the development of large-scale, ozone-generating equipment to produce ozone efficiently and economically. Ozonators were developed which met these requirements, and an ozone plant with a rated daily capacity of 1,250 lb. was put in operation about 6 years ago in Philadelphia. Operation of that plant has demonstrated that ozone can be produced efficiently and in quantity every day of the year in an apparatus which operates with little attention to maintenance details.

Although the performance at the Philadelphia plant was gratifying—it

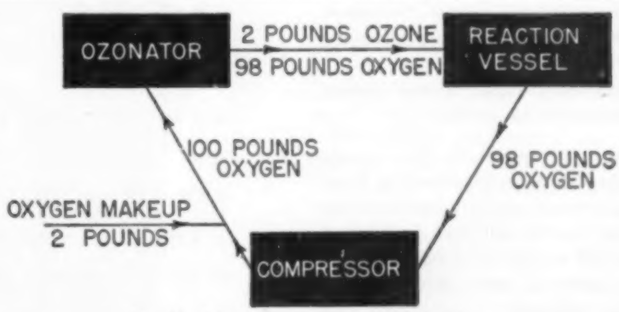
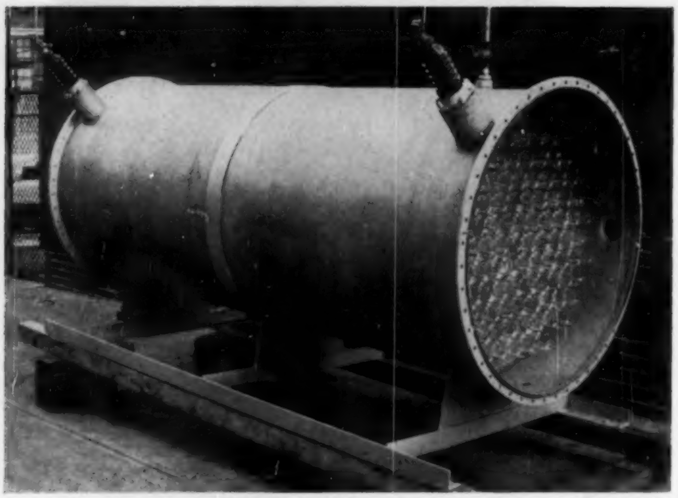


Fig. 1. Schematic oxygen recycling system.



Closeup view of the Welsbach G-204 ozonator, such as those installed at Emery and other large ozone plants.

demonstrated that ozone at 20 to 30 cents/lb. was available—nevertheless the Philadelphia company began at once to search for further major improvements.

As stated previously in this paper, it is characteristic of ozonators that more ozone is produced with oxygen than with air. With ozonators of the Welsbach design, this ratio of output is approximately two to one. Because fixed investment charges and electrical energy consumption account for almost the entire cost of a pound of ozone, use of oxygen feed appears economically attractive. However, with only 2% oxygen being converted to ozone, the cost of oxygen—even tonnage oxygen—would more than offset any savings in equipment or electrical costs.

From these facts the question emerges: Is there no way to avoid wasting the unused oxygen? Fortunately, there is a solution, and it is an effective one, illustrated schematically in Figure 1:

(a) Ozone is generated from oxygen at any convenient concentration, say 2%.

(b) The ozone is then applied to the process desired—some oxidation reaction, for instance —in which the 2% ozone is used up and the 98% oxygen remains.

(c) The unused 98% oxygen is then collected and returned to the ozonators.

With this arrangement the advantages of improved yield resulting from the use of oxygen are obtained and the oxygen cost is still held to a low figure. Instead of 20 to 30 cents ozone is had at 15 or even 10 cents or less under favorable conditions.

There is a clean-up problem to be solved before the oxygen can be recycled to the ozonators. Any oxygen for ozonator feed must be of a peculiar purity. It must be very dry and contain less than 1 p.p.m. organic vapors.

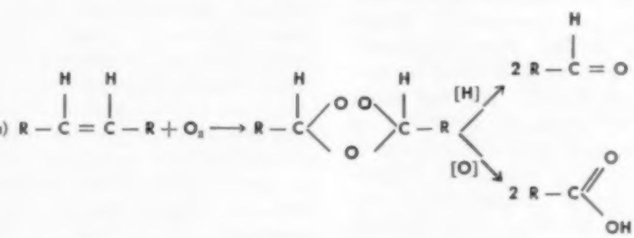
In most ozonizations of practical interest it is not difficult to maintain concentrations of organics below about 100 p.p.m. by proper choice of temperature and solvent, by careful reactor design, and by the use of mechanical barriers. Cutting the concentration down to less than 1 p.p.m. turned out to be a major engineering problem.

While there were several possible approaches to this problem, a solution was sought that would cost as little as possible and yet be generally applicable to almost any oxygen recycling problem.

Water vapor was easy to remove, and it was found that carbon dioxide could be tolerated in the concentrations involved, hence a good approach appeared to be that of *burning* the impurities. Combustion had to be virtually complete (less than 1 p.p.m. of unburned material) and as economical as possible. Now, complete combustion requires high temperatures—perhaps 700° C. or more —and, since the organic matter to be burned is present only in traces, there is far too little to supply the heat required.

To hold down the cost, a method was needed for oxidizing traces of organic vapors to CO_2 and water at relatively low temperatures, *i.e.*, catalytic combustion. A number of combustion catalysts were investigated and several were developed which would insure complete combustion at 300° C. By the addition of a little ozone

Table 1.—Typical Reactions of Ozone

(a) 

(b) $R-S-R+O_3 \longrightarrow R-\overset{\displaystyle O}{\overset{\|}{S}}-R+O_2$

(c) $R-\overset{\displaystyle O}{\overset{\|}{S}}-R+O_3 \longrightarrow R-\underset{\underset{\displaystyle O}{\|}}{\overset{\displaystyle O}{\overset{\|}{S}}}-R+O_2$

(d) $2\ Fe^{++} + 2H^+ + O_3 \longrightarrow 2Fe^{+++} + H_2O + O_2$

(e) $Mn^{++} + H_2O + O_3 \longrightarrow MnO_2 + 2\ H^+ + O_2$

(f) $CN^- + O_3 \longrightarrow CNO^- + O_2$

(g) $2\ NO_2 + O_3 \longrightarrow N_2O_5 + O_2$

(h) $H_2S + O_3 \longrightarrow H_2O + SO_2$

(i) $3\ SO_2 + O_3 \longrightarrow 3\ SO_3$

to assist in the process, better results were obtained. For example, temperatures as low as 150-175° C. were found to be effective when ozone was added to the contaminated oxygen stream. Even with temperatures as high as 300° C. and with simple heat exchangers, it is possible to carry out this catalytic combustion at a cost of only a small fraction of a cent per pound of ozone generated.

Experience with this technique is still limited, but it reveals that it works with the organic materials most likely to be encountered. The removal of compounds containing halogens, sulfur, or nitrogen may require scrubbing after combustion. For most other cases simply drying will suffice. Future ozone plants involving recycle of oxygen containing organic impurities will be equipped with catalytic combustion equipment as an integral part of the plant.

Explosions

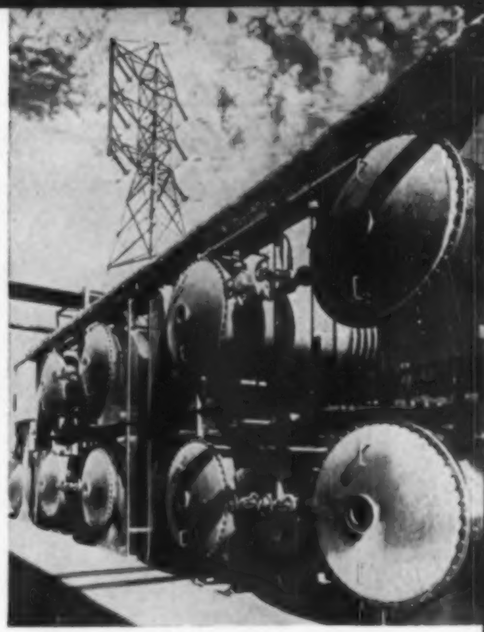
Care must be taken to prevent the combustion in the combustion unit from spreading to the reactor, where there may be a combustible mixture of organic material and of oxygen.

Although the amount of organics in the ozone-stripped oxygen stream is normally well below the combustible limit, curious things can happen. For instance, if the recycled oxygen contains organic vapors, mists, or sprays, this condition can produce deposits of organic materials, ozonides, and ozonide decomposition products on the surfaces of piping and apparatus. Some of these organic materials may have low ignition temperatures–perhaps lower than 100° C. If these organic films in the presence of pure oxygen are ignited in some way, combustion will take place easily and flame will propagate rapidly along the film. Even though the composition of the gas appears to be safely outside combustible limits, the oxygen-film system–in pipes, for instance–acts very much as if a mixture of combustibles were present. In long lengths of pipes or columns, the traveling flame front can build up in speed and pressure to the point where a detonation will result.

Even if every effort is made to design a system to avoid inducing ignition, fortuitous ignition is always possible through static, friction, localized heat of reaction, or accident. Is there a safe way out? The military has been interested in this type of problem for a long time. For instance, how does one avoid blowing up an airplane when its gasoline tank is pierced by an incendiary bullet? Like many tough problems, that one has been effectively solved—by stopping the explosion in the gas tank before it has a chance to get started. And exactly the same principle can be, and has been, applied to explosions in chemical equipment, coal mines, or storage tanks.

The possibility of *suppressing* explosions of inflammable vapors was first explored by the Royal Air Force. It was discovered that there was a short but measurable time interval between the ignition of an explosive mixture and the development of a destructive explosive force. Particularly it was discovered that the initial pressure rise to perhaps 1.5 or 2.0 lb./sq.in. was slow compared to the speed of pressure rise which followed.

It was found that in an ideal vapor-air mixture exploding in a 1-gal. tank, the pressure rises from 0 to 0.5 lb./sq. in. in 5 msec., to 1.5 lb./sq.in. in 10 msec., and to about 90 lb./sq.in. in 40 msec. The comparatively small pressure increase in the first 15 msec. suggested that an explosion could be suppressed before it became damaging if only it could be detected in time. It was found possible to do this, and successful explosion suppression systems have been developed for industrial, as well as military, purposes.



View of Cincinnati ozone plant of Emery Industries, Inc., for the oxidation of oleic acid.

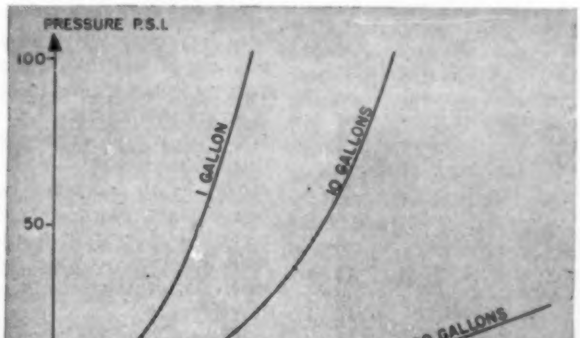


Fig. 2. Typical pressure/time curves for vessels of various volumes.

materials

To understand this technique of explosion suppression, it is necessary to know something about the characteristics of an explosion.

An explosion of the type under consideration here—a mixture of organic vapors and oxygen—is not an instantaneous occurrence but requires a definite and calculable time from the instant of ignition to the development of maximum pressure. For a point source of ignition the time necessary to reach a given pressure follows approximately a cube law. The volume commences as a tiny sphere and grows as a sphere whose radius is expanding at a constant rate. The pressure at any given instant is thus proportional to the volume of the sphere or the cube of its radius. When the flame has filled the vessel in which this is taking place, all the inflammable mixture will have burned and the pressure will have reached a maximum. From this radial

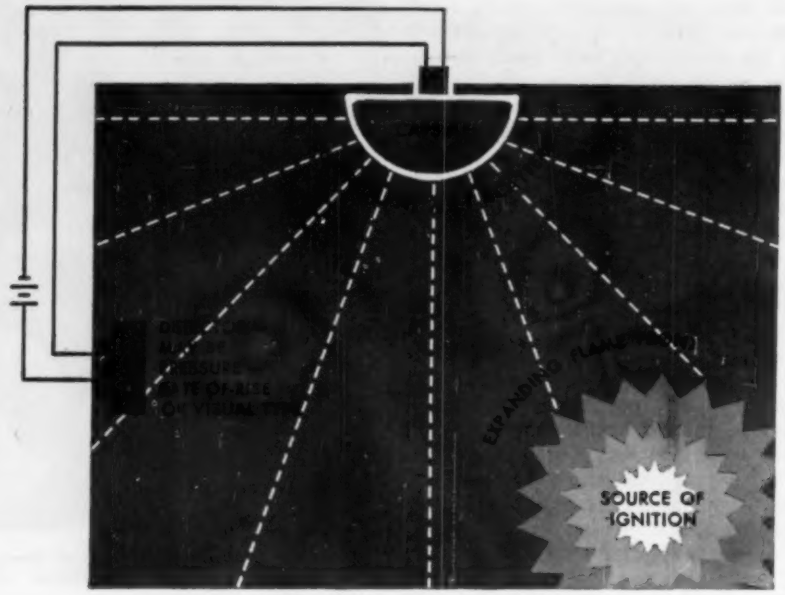


Fig. 3. Basic elements of explosion suppression system.

growth of flame at constant speed it follows that the larger the vessel the longer is the time taken to reach a given pressure. Actually, the time taken to reach a given pressure varies as the cube root of the volume. Typical pressure-time curves for vessels of various volumes are shown in Figure 2.

The final pressure depends on the initial pressure at which the explosion starts. In an ideal hexane-air mixture an explosion starting at atmospheric pressure (15 lb./sq.in.) develops a maximum pressure of approximately 110 lb./sq.in. At 2 atm., the final pressure would be about 220 lb./sq.in.

The cube law holds for vessels where the length to diameter ratio is small and for a point source of ignition. It is modified in the early stages of pressure increase if there are several sources of ignition. Fortuitous explosions approximate a point source.

Mechanism of a Detonation

In long pipes or ducts where the length-diameter ratio is of the order of 30:1, the ignition of explosive mixtures results in a rate of pressure rise which departs from the cube law. In such cases rapid rates of rise may occur, resulting in ultimate pressures of the order of several thousand pounds per square inch. Explosions of this type are known as detonations. A detonation develops in the following stages:

(a) After ignition, the pressure follows a cube law until the sphere of flame has grown to such a size that it fills the cross section of the pipe.

(b) At this stage the pressure-time curve departs from the cube law and follows approximately a square law.

(c) As the flame progresses along the pipe, the gas in its path is compressed more and more and the energy in the flame increases.

(d) A stage is reached where the pressure in front of the traveling flame is very high and the heat radiated from the advancing flame is sufficient to cause practically instantaneous ignition of the large volume in front of it. The resulting almost instantaneous increase in pressure culminates in a detonation.

Although the foregoing may be an oversimplification of a difficult problem, it is sufficient to make clear that the initial rates of pressure rise in explosions, even in pipes, are low. The problem of explosion protection in pipes or ducts is no more difficult than in vessels of low length to diameter ratio. If the explosion is to be suppressed, it is merely necessary to insure that this is accomplished by quenching the flame before the critical length-diameter ratio is reached.

An Explosion Suppression System

In order to suppress an explosion, three units are required: a detector, an electrical power unit, and a suppressor. Such a system is shown diagrammatically in Figure 3.

The detector unit can be of a visual or a rate-of-pressure-rise type. Visual detectors actually "see" the explosion, and rate-of-pressure-rise detectors sense any abnormal increase in pressure. With either type of detector, action must be fast. With a rate-of-pressure-rise detector, the speed is limited by the speed of sound, which travels at about 1 ft./msec. Visual detectors intrinsically are even faster. For effective explosion suppression, the detector must operate while the explosion flame is small and there is plenty of time to extinguish it by ejecting a suppressant into the space where the explosion is taking place. It is fundamental that the speed of ejection of suppressant must be much faster than the speed of flame travel; this can be achieved only by using explosive methods to disperse the suppressant.

For this purpose one uses electrically fired detonators, which have an inherent time lag of less than 1 msec. after the detector contact closes. The detonator is placed in a receptacle in such a position that it will explode a capsule of suppressant material and distribute it rapidly as an expanding hemisphere of fine droplets, which immediately vaporize while moving at a speed of more than 200 ft./sec., which is, of course, much faster than the speed of flame travel.

The action of the suppressant is twofold: it extinguishes the flame partly by chemical action and partly by cooling and at the same time poisons the unburned explosive mixture so that it can no longer burn.

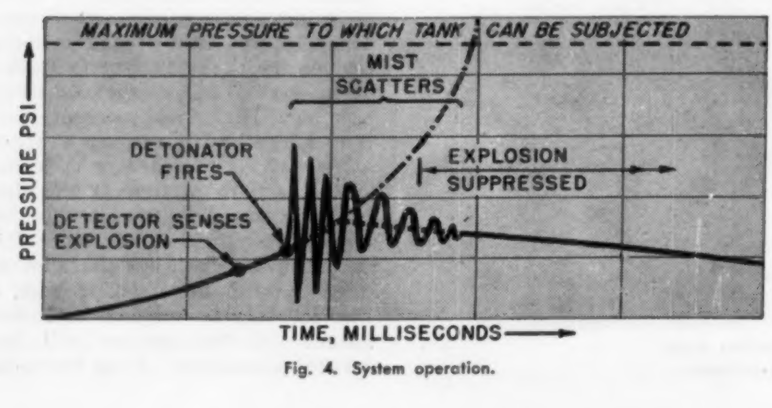


Fig. 4. System operation.

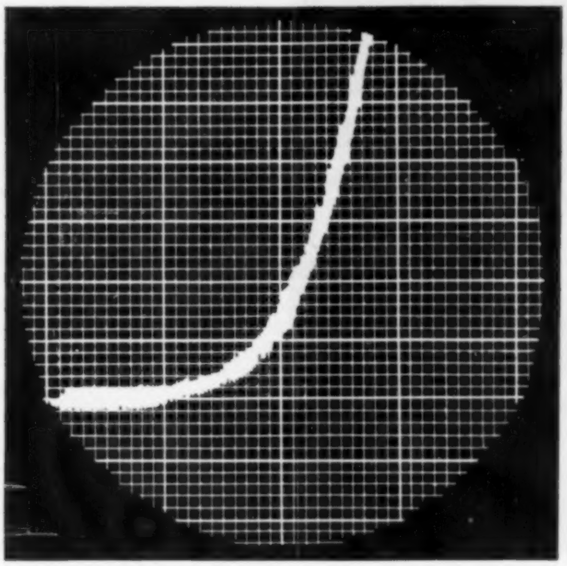


Fig. 5. Oscillograph record—typical unprotected explosion.

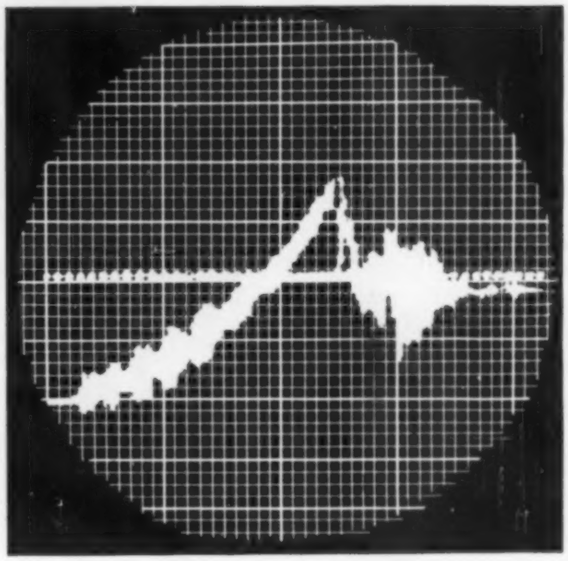


Fig. 6. Oscillograph record—typical protected explosion.

In Figure 4 a typical pressure-time curve for a suppressed explosion is shown. The dotted line shows what would have happened had the explosion not been suppressed.

Figures 5 and 6 are actual oscillograph plots of unsuppressed and suppressed explosions.

Fortunately, the larger the tank the more time is available for ejecting suppressant, and high rate suppressant discharge devices have been developed with sufficient speed to provide a reasonable safety margin in any size vessel.

The electrical power unit requires a d.-c. supply to obtain maximum operating speed. The unit also incorporates various safeguards in case of power failure so that the system is virtually foolproof.

It might also be stated that, as an alternate to suppression, the system can be used to provide pressure *relief* by means of devices, such as bursting disks or quick-acting valves, all detonator-operated if relief rather than suppression is desired.

Characteristics of various ozonation explosions in the Welsbach laboratories have been studied and a conclusion has been reached that these explosions are of a type which can be readily suppressed with available equipment. Explosions of typical ozonides and ozone-reaction products have been suppressed so that it has been established that a properly designed suppression system can prevent explosions under simulated operating conditions.

Whereas it is understood that an ozone reaction system should be designed to avoid any possibility of fire or explosion, some chance for human error must be recognized. It is the belief of the author that explosion suppression is a relatively cheap but positive protection against such human errors.

Ozonide Hazards

Many ozonides are unstable, and all ozonides should be handled with caution until careful studies of their stabilities have been made. In case of unstable ozonides, temperature control is important. Almost any ozonide will decompose spontaneously if the temperature is sufficiently raised. In general, attempts to isolate ozonides should be avoided and the ozonide should be hydrolyzed and oxidized or reduced promptly. Dilution with solvents or inert gas will also minimize ozonide hazards.

Particularly where relatively high concentrations of ozone are employed, the heat of reaction may cause a localized temperature rise, which, in turn, can decompose the ozonide and cause a fire or explosion. Such conditions can be avoided by proper design of the mixing equipment, by dilution with inert gas or with solvent, by reduction of ozone concentration, or by a combination of these requirements. The important points are to recognize that the ozonide is unstable above a certain temperature and to design the reaction equipment such that temperatures remain safely below the danger point and conditions of localized heating are entirely eliminated.

Some ozonides, such as oleic acid ozonide and ozonides of similar large molecules, are relatively stable and can be handled or stored with little hazard. However, there is always a possibility that an unintentional introduction of water or metal may catalyze an ozonide decomposition which could be hazardous.

materials

Ozone Toxicity

It might also be pertinent here to state that ozone itself is a toxic gas and should be respected as such. It has about the same order of toxicity as chlorine but is considerably less dangerous because chlorine is handled in 100% concentration as compared to perhaps 1 or 2% for ozone. Ozone is also largely self-policing, in that low and relatively harmless concentrations are extremely irritating and readily detectable.

There is considerable controversy over the maximum permissible ozone concentration for continued exposure. It is believed that a maximum permissible concentration of about 1 p.p.m. is reasonable, and that precautions should be taken to avoid continuous exposure to concentrations higher than that amount. Any ozone leak is an indication of ozone loss, and it is only sensible to eliminate all such leaks.

Acknowledgment

The generous assistance of the Graviner Manufacturing Company of England and its sole American licensee Simmonds Aerocessories, Inc., designers and manufacturers of explosion suppression systems, in furnishing information, photographs, and diagrams is herewith acknowledged.

In this picture dryer is set up for 100% recovery in cyclone collector—no chamber collection.

FACTORS AFFECTING Particle Size IN A SEVEN-FOOT Spray Dryer

F. W. Meyer

Bowen Engineering, Inc.
North Branch, New Jersey

The purpose of this work was to determine what correlation, if any, exists between the findings of previous rotating-disk atomization studies and the results attained in actual spray-dryer operation. Much of the previous work was carried out at feed rates of under 10 lb./min. and peripheral speeds of less than 10,000 ft./min. Since most commercial spray dryers operate at feed rates and wheel speeds higher than this, an auxiliary purpose was to determine if correlations between particle size and peripheral speed and feed rate held true at these higher levels.

Test Procedure

Test runs were made in a 7-ft. diam. cone-bottomed drying chamber, arranged for product collection at the bottom of the chamber. Particles not separated at the chamber bottom were drawn from the chamber with the drying air through a side-entering duct. This fraction was separated in a high-velocity cyclone dust collector. Over-all recovery was on the order of 98% and of this, an average of ⅔ of the sample was collected in the cyclone. In computing average particle sizes, the weight per cent of powder collected in the cyclone was multiplied by .75 to allow for deterioration of particle size in the duct work and cyclone.

The material selected for these tests is a slurry containing particles less than 1μ in size. Drying of this slurry results in the formulation of solid spheres consisting of agglomerates of the original submicron particles. It is felt that these solid spheres are more representative of the original wet drop size than the hollow spheres formed in the drying of many materials. In the latter case the film-forming properties of the material affect particle size. The material used is not heat sensitive, which permitted the use of a 1,000° F. inlet temperature necessary for drying comparatively large particles in a 7-ft. chamber. The dry powder had the further advantage of excellent flowability, thereby simplifying the sieving operation. Particle-size attrition in the duct work was minimized by the relative hardness of the particles. Two formulations of this material were dried, one containing 50% solids and having a viscosity of about 330 centipoises, the other containing 18% solids and with a much higher viscosity. The properties of each material are given in Table I.

Ten runs were made. A summary of the operating conditions of these runs is presented in Table 2.

The chamber and cyclone sample collected from each run was screened. The size of the −325-mesh cut was inspected microscopically to determine average size. The cumulative weight per cent less than a given size was plotted against particle size on a logarithmic scale since the logarithmic distribution is reported to be a truer representation of drop-size distribution than the arithmetic. The mass median diameter was then found at the 50% coordinate. After adjusting the weight per cent of the cyclone sample downward, the over-all average particle size of each run was determined by a weighted average of the chamber and cyclone samples.

Sources of Error

Errors in the results may have been introduced from four sources:

1. the 2% of fine powder not recovered.
2. by the judgment on weighting of the cyclone and chamber product to allow for abrading of the particles in the ducts and cyclone.
3. by the estimate of the average particle size of the −325-mesh sample from microscopic examination.
4. wall deposition in run no. 7. This condition eliminated some of the larger particles from sample.

Table 1.—Properties of Test Materials

Feed material	Physical form	Per cent solids	Specific gravity	Viscosity centipoises
1	Slurry	50	1.44	330*
2	Slurry	18	1.12	6800*

* Material is thixotropic. Viscosity measured at 60 rev./min. on Brookfield viscometer.

It is not felt that these would result in any gross errors.

In comparing the data from this experiment with other atomization studies, it should also be borne in mind that the average particle size has been determined on a weight basis whereas many investigators have used a counting method. And as was pointed out earlier, the solid sphere formed in this experiment is presumed to be proportional in size to the original wet drop in which case the phase change would not affect the results. In a majority of the previous experiments, however, the liquid drop size was determined.

Results

The average particle sizes were plotted against peripheral speeds and feed rates on log-log paper. A straight line drawn through the peripheral speed plot showed the particle size to vary inversely as the square of the peripheral speed. It would be more accurate perhaps to draw a curve through these points, however, with the slope of the curve at lower peripheral speeds showing the particle size to vary inversely as the .69 power of the peripheral speed, but in the upper ranges the size varies as slightly more than the square of the speed.

The other seven runs demonstrated that particle size varied directly with the feed rate, but to a varying degree. The effect of feed rate was least in the runs made with the less viscous material, the exponent being .21. In the same range of feed rates, under 10 lb./min., but with the more viscous material, the effect of feed rate increased to the 0.37 power while at rates of more than 10 lb./min. with the viscous material, the feed rate was more important, the exponent increasing to .67.

DISCUSSION OF RESULTS

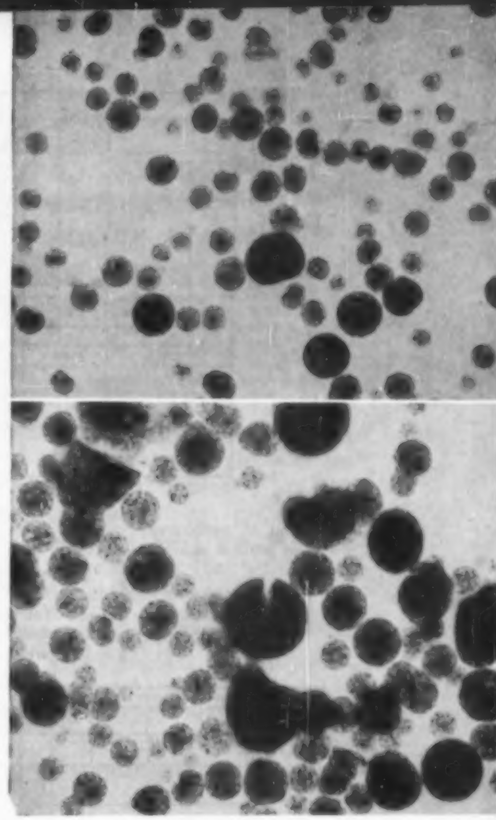
In a well-known discussion of the mechanism of drop formation with centrifugal disks, Bar (*2*) referred to two different actions taking place. At low-feed rates he described a break-up of the liquid film on the disk surface, with individual drops being thrown from the periphery of the disk. A formula he developed for this type of atomization shows the drop size to be inversely proportional to the first power of the peripheral speed.

The second case is referred to as velocity spraying. Here the liquid comes off the disk periphery as a sheet and the break-up into ligaments and drops takes place some distance from the disk. In this instance the formula he developed showed drop size to be inversely proportional to the square of the peripheral speed. Photographs taken by Hinze & Milborn (*5*) provided evidence of these two types of atomization, as well as an intermediate step in which ligaments appeared at the disk periphery, instead of either a sheet of liquid or discrete drops. Adler & Marshall (*1*) surmised that the velocity spraying mechanism would take place at higher peripheral speeds, and higher feed rates.

It seems likely that velocity spraying will be promoted by higher viscosity liquids. It might also be expected that the effect of feed rate, through control of the thickness of the film, would be much greater in the case in which the break-up took place outside the disk than when the formation into ligaments and drops takes place on the surface of the disk.

This experimental work, as well as some data obtained by previous investigators, seems to support this possibility. In several runs in which a cup-type atomizer was used, the data of Friedman, et al. (*3*) show drop size inversely proportional to the periphery speed to the .9 power. This was at speeds under 15,000 ft./min. and using a nonviscous feed material [1 centipoise] at a 10 lb./min. feed rate. Wallman & Blyth (*6*), with another nonviscous material [12 centipoise] and at low-speed rates of 2 lb./min., reveal the peripheral speed affecting particle size to the .6 power. Presumably these are instances of direct drop or ligament formation where, according to Bär, the drop size is inversely proportional to the first power of the peripheral speed.

In the test work on which this paper is based, at peripheral speeds more than 25,000 ft./min., with a 10 lb./min. feed rate of high viscosity material [6,800 centipoises] apparently velocity spraying occurred since the exponent was found to be 2.1. However, there was a perceptible decrease in this exponent at the lower speeds and a line tangent to the curve here shows an exponent of 0.69. This suggests the possibility that velocity spraying begins at peripheral speeds of 20,000 to 30,000 ft./min. A comparison of this experimental data is shown in Figure 1.



TOP—Chamber sample, run No. 1, 3 lb./min.; feed rate, 42 μ avg.

BOTTOM—Chamber sample, run No. 3, 12 lb./min.; feed rate, 55 μ avg.

Increase in particle size with higher feed rates is clearly evident as well as some decrease in uniformity at the higher rates. The micron-size particles which have agglomerated to form the spheres are apparent. Photomicrograph 250 diam. by *Roy Allen*.

equipment

The changing atomization mechanism is even more apparent from a study of the effect of feed rates. At feed rates of less than 5 lb./min. and with a nonviscous material [15 centipoises] Wallman & Blyth found the feed rate to affect particle size only to the .11 power. Friedman et al., on the basis of 16 runs, found that particle size varied directly as feed rate to the .2 power. Several runs selected from their data in which a cup-type atomizer similar to that employed in the present experiments, was used, however, show the feed rate affecting

Table 2.—Summary of Pertinent Test-Run Data

Run No.	1	2	3	4	5	6	7	8	9	10
Controlled Variable		Feed Rate			Feed Rate				Disk Speed	
Feed material, % conc.	50			18				18		
Feed rate, lb./min.	3	8	12	3	8	12	16	9	10	10
Feed temperature, ° F.	70°									
Atomizer type	Inverted bowl, round edge							Inverted bowl, sharp edge		
Atomizer diam., in.	5							7		
Atomizer speed, rev./min.	21,000							14,000	18,000	21,000
Peripheral speed, ft./min.	27,500							25,600	33,000	38,500
Mass average particle size, μ	31	38	41	26	37	69	83	57	46	24

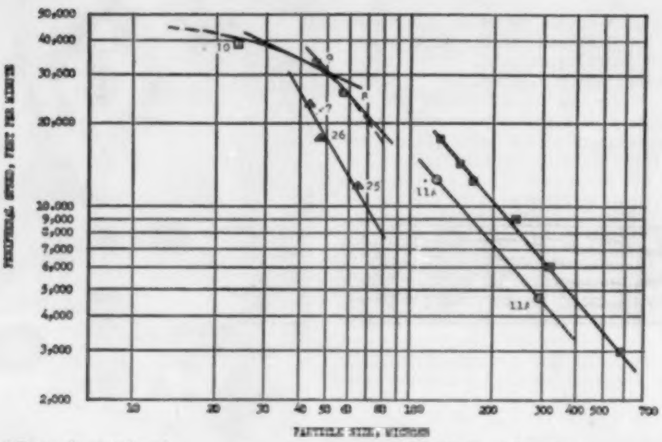


Fig. 1. Effect of peripheral speed on particle size.

	Source	Feed Rate lb./min.	Viscosity centipoise	Slope
Figure 1.	☐ Bowen	10	6,800	upper 2.1 lower 0.7
	△ Wallman *et al.* (*6*)	2	14	0.6
	○ Friedman *et al.* (*3*)	10	1	0.8
	⊠ Herring *et al.* (*4*)..	20	1	0.8

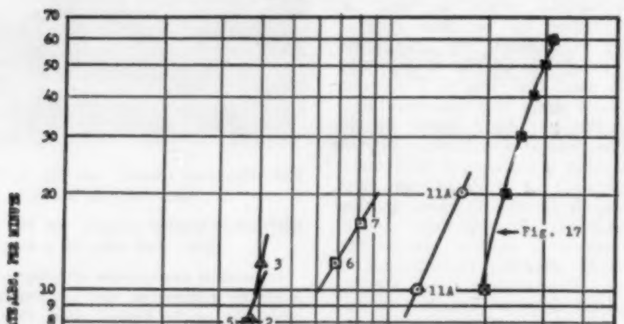


Fig. 2. Effect of feed rate on particle size.

	Source	Peripheral speed, ft./min.	Viscosity centipoise	Slope
Figure 2.	△ Bowen, runs 1-3 ..	27,500	330	0.2
	☐ Bowen, runs 4-7 ..	27,500	6,800	lower 0.4 upper 0.6
	⊗ Wallman *et al.* (*6*)	11,800	15	0.1
	○ Friedman *et al.* (*3*)	12,600	1	0.4
	⊠ Herring *et al.* (*4*)..	9,000	1	lower 0.2 upper 0.35

Numbers adjacent to plotted points refer to run num bers or figure numbers in author's data.

particle size to the 0.4 power. This is with a low viscosity [1 centipoise] feed material and at a peripheral speed of 12,600 ft./min. Data presented by Herring & Marshall (*4*) show an increasing effect due to feed rate as the rate increased from 10 to 60 lb./min., the exponent in the lower range being .23, while at the higher rates the slope has increased to 0.35. These runs were made with a feed material having a viscosity of 1 centipoise at 9,000 ft./min. peripheral speed.

These results have been plotted on Figure 2 along with the data from this test. A study of this figure reveals that at feed rates under 10 lb./min. there is an increasing effect of feed rate on particle size from low- to high-viscosity materials. There is another general increase in the effect of feed rate at rates of more than 10 lb./min. and here again higher viscosity feed materials and greater peripheral speeds seem to result in the particle size being controlled to a greater extent by feed rate. As stated previously, it would seem to follow that if the mechanism of atomization was break-up on the disk, with particles or ligaments being formed on the disk periphery, the feed rate would have little or no effect on particle size. On the other hand, if a solid sheet of material leaves the disk periphery and breaks up due to liquid-air friction at some point outside the disk, one can imagine that increases in feed rate with resulting increases in film thickness would have a marked effect on particle size.

This test work does not provide enough information to form any firm conclusions. There does not seem to be, however, any conclusive agreement thus far on the effect of peripheral speed and feed rate on particle size. Perhaps the problem should be divided into two parts.

The first part would be a confirming study of previous test work on the effect of these two variables on particle size in the lower ranges when drop formation occurs on the disk. The second would be at feed rates of more than 10 lb./min. and peripheral speeds of more than 15,000 ft./min., the range more normally occurring in commercial applications, to determine how particle size is controlled in these ranges. The viscosity of the feed material appears to be important also in determining when velocity spraying supplants drop spraying. (When comparing studies using vane- and cup-type atomizers, the feed rates should be given in lb./min./ft. of wetted periphery.) Finally some means of determining the point at which the transformation takes place would be of value.

Acknowledgment

In conclusion the writer expresses his appreciation for the efforts of J. V. Russo & R. Schauer of the Bowen organization, who operated the spray dryer and collected data during these test runs, as well as to the management of Bowen Engineering, Inc. for its encouragement and cooperation which made this investigation possible.

Literature Cited

1. Adler, C. R., and W. R. Marshall, Jr., *Chem. Eng. Progr.*, **47**, No. 10 and 12, 515, and 601 (1951).
2. Bär, P., Dr. Eng. Thesis, Technical College, Karlsruhe, Germany (1935).
3. Friedman, S. J., F. A. Gluckert, and W. R. Marshall, Jr., *Chem. Eng. Progr.*, **48**, 181 (1952).
4. Herring, W. M., and W. R. Marshall, Jr., Paper presented at A.I.Ch.E. meeting, St. Louis (1953).
5. Hinze, J. O., and H. Milborn, *J. Appl. Mechanics*, **17**, 14 5 (1950).
6. Wallman, H., and H. A. Blyth, *Ind. Eng. Chem.*, **43**, 1480 (1951).

STRAUSS AT CLEVELAND —PAPERS AVAILABLE

● **Admiral Lewis L. Strauss,** chairman of AEC, heads list of speakers at Cleveland Nuclear Congress' All-Congress Dinner on Wednesday, December 16. EJC's president, Thorndike Saville, welcomes diners, W. L. Cisler, Detroit Edison president, does the toastmastering. Introducing Strauss is J. R. Dunning, Columbia's engineering school dean.

● **Papers to be given at Congress** have been pre-printed, are now available from A.I.Ch.E.'s national secretary, F. J. Van Antwerpen, in New York office.

● **Some 150 U. S. and foreign exhibitors** already lined-up for concurrent Atomic Exposition. Every major industry is represented from chemicals and power to agricultural equipment and automobiles.

STANDARDS COMMITTEE FORMED

New Committee, headed by J. C. Lawrence, to investigate and develop standards and codes of interest to the chemical engineering profession and the chemical industry, held first meeting Sept. 16th.

Its membership covering a wide range of technical skills and industry experience, A.I.Ch.E.'s new 15-member Standards Committee is already hard at work, is ready and anxious to receive any ideas for standards and codes members may have.

While the actual development of standards and codes will eventually form the major part of the Committee's work, it is now devoting much time to proper representation of A.I.Ch.E. on such organizations as American Standards Association, A.S.T.M., and others concerned with standards chemical engineers are interested in. Close cooperation with these bodies is vital to both the Institute and the Committee itself.

The Committee will carry on its work through working sub-committees, each appointed to develop the particular standard or code suggested by the membership for study. Any group or individual may suggest such a standard, the idea will be considered by the full Committee, and, if worthwhile, will be assigned to a sub-committee for work. Each sub-committee has a member of the Standards Committee as chairman, with three other members selected from Institute membership according to their special skills and experience in the area under study.

The only permanent sub-committee is the one on Work Program, which has the job of pre-screening suggestions before they go to the full committee for assignment to working committees. The chairman of this sub-committee is the full committee's vice chairman, at present, G. F. Jenkins.

Fully organized and underway, the Standard Committee is ready for any suggestions the membership may have in this field of rapidly growing importance.

COLLEGE PROGRAMS IN NUCLEAR ENGINEERING

The rate of development of interest in nuclear engineering is one of the remarkable phenomena of our times. Realizing that the key to success in this field lies in well-trained technical manpower, A.I.Ch.E.'s Nuclear Engineering Division has sponsored a detailed survey of just what is being done in Nuclear Engineering Education.

The study, titled "College Programs in Nuclear Engineering," gives full details on all college courses in the field, is available from A.I.Ch.E.'s national headquarters in New York.

STUDENT CONTEST PROBLEM PRIZE AWARDS

Problem contest winners (l. to r.) Baron, Hartman, and Zahner.

Arthur L. Baron, First Prize, Cooper Union, New York. Now with Esso Research and Engineering, Linden, N. J.

John C. Zahner, Second Prize, Univ. of Illinois, 1956 graduate.

Ronald L. Hartman, Third Prize, Louisiana State Univ. Now with Shell Oil, Norco, La.

Leon Lehman, Honorable Mention, Cooper Union, New York. Now graduate student, Univ. of Michigan.

Paul E. Otto, Honorable Mention, Louisiana State Univ. Now with DuPont, Victoria, Tex.

Gene M. Pettingill, Honorable Mention, Univ. of Colorado. Now with DuPont, Gibbstown, N. J.

A.I.Ch.E. COUNCIL RELEASES POLICY STATEMENT ON PROFESSIONAL STANDARDS

R. P. Dinsmore, a director of the Institute, and Chairman of the Special Committee which made the study leading to the preparation and release of the document appearing on the following three pages, has given us these words of introduction to the highly significant document.

When the Council of the Institute began to discuss what they might do to aid their fellow members to attain higher professional recognition, it was found that many of their ideas about professional standards were difficult to formulate. It was recognized that little of value could be achieved unless experience and objectives could be stated in comprehensible language and agreed upon by the Council and its advisors.

The following statement is the result of much study and patient analysis, followed by discussion and reworking. It is probably incomplete and undoubtedly imperfect, but it should challenge the interest of every professional man who has any conscientious feeling about his professional obligations. If it likewise helps employers and members of the public to understand the professional viewpoint a bit more clearly, it will have an added value.

Publication of this document will not in itself be of importance unless it is examined critically, corrected or augmented where necessary, and used to promote those standards which it professes to discuss. Many will find it a useful base from which to operate.

Ray Dinsmore

Professional Standards

A STATEMENT BY THE COUNCIL OF
THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

This statement has been prepared for the guidance of members of the American Institute of Chemical Engineers—particularly committee chairmen—whose official duties require them to acquaint others with the professional standards advocated by the Institute. A definite exposition of the official views of this Society is given here so that practicing engineers, teachers of chemical engineering, industrial employers, and the general public may understand the nature and importance of the professional standards of the chemical engineer.

A professional person is an individual who, with adequate training, experience, intellectual capacity, and moral integrity, effectively devotes his skills and knowledge to the service of society and his profession in whatever assignment he finds himself, being fully sensible of the personal responsibility and trusteeship conferred by his special training.

One of the functions of the Institute is to encourage professional attitudes among its members and to obtain public recognition of their profession as of the highest rank. The Council of the Institute has viewed with deep concern a growing tendency among chemical engineers to relinquish their independence of action and to lower their professional status by establishing relationships between themselves and their employers or the public which must be considered directly antagonistic to their professional standing. For this reason the Council has officially stated its position as follows:

> The enhancement of the status of the engineer is best promoted by his reliance upon his personal professional growth and accomplishment, and his status as a professional man is endangered by reliance upon group efforts to act on his behalf in reaching short-range economic objectives. At the same time, a corresponding obligation is laid upon the employer of engineers to give each professional employee his due individual recognition as a member of a profession.

The Council of the Institute, it should be emphasized, seeks to promote the professional stature of its members — not by opposing any other group or organization but by recommending high professional standards and working for their acceptance by the chemical engineer and by all those with whom he comes in contact.

The Chemical Engineer

Much is said today about the need for improving the professional status of engineers and scientists, but this aim has different meanings for different people. To some it means simply that professional people should be more highly paid for their efforts; to others it means that they should have more dignity and personal freedom and recognition by their employers and the public; to still others it means that professional people themselves should adopt stricter standards for their professional activities and should take more active interest in the improvement of their own professions.

Whatever the interpretation, however, the achievement must be sought largely by engineers and scientists who find themselves in surroundings quite different from those which generally prevailed when professional standards were conceived. These constantly growing groups of professional people are becoming part of modern corporate structures and therefore must conform to the procedures of business as well as to their professional codes. It is a situation weighted less with conflict than with challenge and opportunity.

Historically law, medicine, and theology were referred to as the "learned professions" and their practice or teaching was associated with certain recognized standards of professional conduct, which at times in history were quite definitely laid down and formally accepted by the members of those professions. Conformity to these codes of conduct was just as essential to professional acceptance as was proficiency in special skills, and in many cases more so. Since all professions are influenced by traditions handed down by the original learned professions, it is important to examine the reasons for the persistence of these ideas.

Because members of the learned professions had knowledge and skills which were neither possessed nor understood by the majority of the lay public, the people who consulted them were obliged to accept their services on faith. Moreover, in the process such professional persons frequently accepted confidential information which could not be divulged without danger to the confider. Hence public confidence in the learned professions required that they should maintain a reputation for integrity in protecting confidential disclosures.

The early members of the learned professions obtained their initial training almost entirely from individual teaching by older practicing members of their profession. This teaching came by books, by word of mouth, and by a kind of apprenticeship in the practice of professional skills. Therefore, a member of the professions was placed under an obligation to teach others and to advance his profession by adding to its knowledge where possible and by upholding the public reputation upon which continuation of the profession depended.

Engineers and scientists have similar professional obligations today. Their skills are understood only vaguely by the lay public. Their services are essential to the furtherance of the needs of modern society, and these professional men have a debt to society for specialized training. Although not passed on by individuals to the same extent as formerly, this training has its roots in accumulated knowledge which could not be obtained by the professional student in any other way than through the education and other means provided by modern society.

Engineering operations today are varied and extensive. Men at all levels of training and competence are required for the vast far-flung engineering enterprises of our times. Skilled assistance for the engineer, although indispensable, does not necessarily require the imagination and judgment of the man who conceives and executes the broader aspects of an engineering project. It is in the intermediate ground between the craftsman and the engineer—between the trade and the profession—that the difficulty of maintaining professional attitudes lies.

Individual initiative and individual responsibility are basic to the engineer. The initiative to create, the responsibility to provide not only for himself, but for his associates and subordinates an environment in which individual opportunity can find full expression—these are the requisites for the professional man. It is toward their acceptance and enhancement that the Institute is devoting its energies.

Thus the engineering professions place upon their membership obligations which are recognized, at least in part, by codes of ethics set forth by the major professional societies. These codes cannot specify in detail the ethical obligations brought about by the debt which is owed by the individual to his profession and to society as a whole. Even less may they delineate those altruistic professional acts which the professional man may perform without any direct obligation or any expectation of reward except the personal satisfaction which he receives and the added luster that is reflected upon his profession.

Most modern businessmen, relying no longer upon the once popular doctrine of *caveat emptor*, take pride in giving full and honest value for payment received and in maintaining their reputation for honesty and integrity. A large proportion of such businessmen have high ethical standards in dealing with the public and their employees, and they reflect great credit upon their own fraternity. The very fact that business standards are so high, however, misleads many professional men into thinking that these standards are adequate for their own guidance. Nevertheless, these business standards do not meet fully the requirements which have arisen from the special obligations of professional men.

Regardless of his educational background, no individual can expect to be regarded as truly professional unless he adopts a code of conduct and an attitude of mind that reflect a desire to contribute to society and to his profession. Obviously if a professional person forfeits his code of conduct and attitude of mind and his freedom to act in accordance with them, whether that forfeiture be to his employer, to a union, or to anyone else, he has destroyed the foundation upon which his professional status was erected.

Intellectual achievement, dedication to the enhancement of science for the progress of civilization, integrity, and acceptance of the strength of individuality—these are this Council's concept of truly professional characteristics. They are the principles for which the Institute stands.

GENERAL STANDARDS

Detailed codes of ethics for the chemical engineer are too limited and inflexible to meet all professional contingencies. It is preferable, therefore, to set forth only some general rules which have been accepted by professional men of experience, judgment, and strong moral convictions. The following standards are widely accepted by engineers of high professional standing.

A social consciousness which honors the desire to contribute to civilization while recognizing the beneficial influence of the profit motive.

The acquisition of professional skills of a high intellectual character as measured by the most critical standards.

Acceptance as self-evident that one's professional attitude toward the public, one's clients, or one's employers should be the faithful performance of a trusteeship, not to be relaxed because of another's misbehavior.

Placing of the highest value on one's individual initiative and responsibility.

Recognition that tolerance, dignity, fairness, and objectivity add to professional stature.

Acceptance of responsibility by teachers of chemical engineering to indoctrinate their students with the obligations and the nature of a true professional attitude.

Belief that the truly professional man venerates his profession and intensely desires to add to its prestige, its knowledge, and its usefulness to society.

Conviction that dedication to these objectives and to professional integrity enables the engineer to view from the proper perspective profit and personal recognition.

(*Continued*)

The Employer's Influence

Although professional standing will not be destroyed or degraded by any adverse local environment, its free influence and effect may fall short of the ideal if circumstances are sufficiently unfavorable. For example, the professional chemical engineer cannot do his best work or hope to give maximum satisfaction if his employer fails to deal with him as a professional man. The competent employer shares with the individual engineer a determination to maintain the professional character of engineering and sees to it that his organization supports that standard.

Even with the best intentions employers and engineers at times may fail to have a common viewpoint. Progressive employers, however, have found various methods that are effective in promoting good relationships with professional personnel.

PROFESSIONAL RECOGNITION

The following sound practices in dealing with professional people are cited as examples:

Making it obvious that the engineer belongs to the management team and that his findings influence management policy.

Maintaining effective lines of communication from top management to the nonsupervisory engineer.

Establishing that engineers are professional employees as distinguished from technicians and other nonprofessional workers with whom they may be associated.

Awarding as much recognition to the individual professional man as circumstances permit by affording merited opportunity to attend engineering-society meetings and by giving him credit in reports and publications.

Minimizing assigned work of a kind that does not challenge the engineer's ability and capacity.

Exercising care that assignments to engineers conform with recognized professional principles.

PERSONAL RECOGNITION

Consideration of the employer's attitude toward the professional engineer has led to a number of tested principles, which employers doubtless find applicable to other groups of employees as well:

Recognizing each engineer as an individual and always providing an opportunity for him to express his own views.

Encouraging advancement and stimulating professional interest by adopting methods by which progress can be measured.

Instituting a training program through which the promising engineer may prepare for promotion.

Making certain that each engineer is informed periodically of his progress and shortcomings so that it is clear that promotions are based on merit.

Advancing those with superior ability before they become dissatisfied with their future prospects.

Making clear the distinction between job security and opportunity for advancement and the price that must be paid for each.

FINANCIAL RECOGNITION

It is beneficial to base the remuneration of engineers on the following practices:

Keeping a fair and reasonable pay differential between the engineer and the nonprofessional employee.

As hiring rates increase, making corresponding revisions in the existing salary structures.

Maintaining a competitive position as to salaries and merit increases and finding means of assuring the engineering staff that this is being done.

Rewarding merit consistently and avoiding the complaint that it is secondary to seniority.

GENERAL SUGGESTIONS

In general, the employer can assure both the young and the seasoned engineering employee that his professional status is recognized by

Giving the young engineer wise counsel with respect to the course of events in his first few years, when training and experience must precede rapid advancement.

Helping him to learn to appreciate the qualities of leadership and to develop his own leadership talents.

Showing just consideration to the rewards and privileges of the experienced and competent engineer in comparison with those of younger men employed under present circumstances.

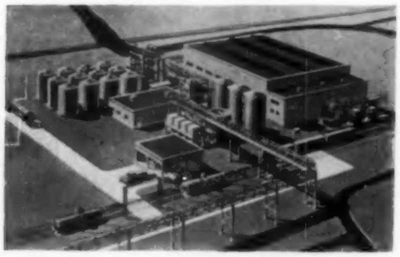
At the time that the American Institute of Chemical Engineers was founded, questions of professional status seldom arose. Today, however, with the forces of technology transforming the world, those whose careers are concerned with its development can no longer ignore the effect of the professional attitude. The Council of the Institute has endeavored, therefore, to crystallize its views on professional conduct in the field of chemical engineering. It is earnestly hoped that members of the Institute will do everything possible to further the ideas here expressed.

INDUSTRIAL NEWS

MAJOR CHLORINE-CAUSTIC PLANT

$5 Million General Aniline & Film plant goes under construction in New Jersey.

New 50-ton/day chlorine-caustic plant of General Aniline at Linden, N. J., will be first of its type built in New York metropolitan area. Designed and being built by Chemical Plants Division, Blaw-Knox, the new plant will produce chlorine, caustic, and other chemicals by the Mathieson mercury cell electrolytic process.



Utilizing water, salt and electric power to produce its chlorine and caustic, the plant will send its output to GAF's plants at Rensselaer, N. Y., and Linden. ☐

Marlex, new rigid polyethylene of Phillips Chemical Company, will be produced at the rate of 110 million pounds per year in a new plant to be built for Phillips by Farnsworth and Chambers Co., Houston. Located at Adams Terminal, Houston, construction is underway on the plant. A Sales Service Laboratory for the important new plastic is also under construction, at Bartlesville, Okla., and Stone & Webster is building a 120-million-pound-per-year ethylene plant for Phillips at Sweeny, Tex., to supply the basic raw material for the new Adams Terminal plant. ☐

Doubled capacity will be the result of the large, new ethanolamines unit being constructed by Carbide and Carbon Chemicals at its Seadrift, Tex., installation. ☐

AEC's projected Engineering Test Reactor is to be built by the Kaiser Engineering Division of Henry J. Kaiser Co. To be built at the National Reactor Testing Station in Idaho, the ETR is expected to be completed by spring, 1957. ☐

Advanced processing and control equipment will be part of Witco Chemical's new metallic stearates plant at Los Angeles, Calif. ☐

New Styrofoam plant of Dow Chemical at Torrance, Calif., will go on stream at the beginning of 1956. Largely open-air construction, the plant is intended to supply Dow's West Coast markets. ☐

Fused magnesia, fused zirconia, boron carbide, and special materials for AEC, will be produced in the Norton Co.'s new Huntsville, Ala., plant. The electric furnace plant, costing $1,285,000, is being built by Daniel Construction Co., Birmingham, is provided with ample space for anticipated future expansion. ☐

A catalytic reformer, main unit in Imperial Oil, Ltd.'s new $5 million Sarnia, Ontario, refinery, is being built by Fluor Corp. of Canada. The unit will have a capacity of 13,500 bbls./day. ☐

Doubled phthalic anhydride output is the goal of Pittsburgh Coke and Chemical's new plant at Neville Island, Pa. Construction of the $3 million plant has started, completion scheduled for Fall, 1956. Engineering and building is being done by the Lummus Co. ☐

Celanese will be first large-scale commercial producer of new thermoplastic, cellulose propionate plastic, to be called Forticel. Volume production is already underway, short molding cycle of new plastic is expected to bring up to 25% increase in production of finished products per machine. ☐

Rapid expansion in the use of vinyl latex paint has caused Bakelite Division of Union Carbide to plan a three-fold expansion of its production of vinyl acetate resin latex, the base resin of the new paints. ☐

Canadian Petrofina, Ltd., has just put on stream a 16,600 barrel-per-day Houdriflow catalytic cracking unit at its new Montreal refinery. Designed to produce high yields of high octane gasoline, the new unit was constructed by the Lummus Co. of Canada.

For producing silica refractories, Harbison-Walker Refractories Co.'s new 100,000 sq.ft. standardized steel factory at Leslie, Md., was built by Luria Engineering Co., Bethlehem, Pa. Plant is 33d in Harbison-Walker's chain, latest addition in $35 million expansion program.

One of Europe's largest broad-spectrum antibiotics fermentation plants has been opened by Chas. Pfizer in Sandwich, Eng. Cost of plant: $7 million. ☐

Expected to be on stream before the end of 1956, new $14 million Southern Nitrogen Co. petrochemical plant is under construction, will produce 250 tons/day of ammonia for conversion into nitrogen solutions and prilled ammonium nitrate. Girdler is prime contractor. ☐

More than 60% increase in production of high-purity industrial lime is the result of the extensive new facilities of U. S. Gypsum Co. at its New Braunfels, Tex., plant. ☐

Plans for a multi-million dollar addition to DuPont's still-being-constructed Antioch, California, plant, are now in the works. Addition will produce sodium, ethyl chloride, trichlorethylene, and perchlorethylene, will adjoin original tetraethyl lead and "Freon" plant scheduled for late 1956. New unit scheduled for early 1957. ☐

Advanced design $25 million chemical cellulose plant with an annual capacity of 100,000 tons will be built at Jesup, Ga., by Rayonier, Inc. The plant is designed to produce not only the latest celluloses, but ones still in the laboratory stage. ☐

New facilities for the production of para-cresol have been added to Hercules' new Gibbstown, N. J., oxy-chemical plant. About 3 million pounds of para-cresol will be produced annually.

This is the sixth product to be manufactured at the new plant. ☐

Construction of a 300 ton per day anhydrous ammonia plant for The Standard Oil Company of California's new multi-million dollar petro-chemical facilities at Richmond, California, is now underway. M. W. Kellogg is contractor. ☐

The advancing chemical engineering frontier —

LAKE PLACID NATIONAL MEETING

and two recent sectional affairs

If it is possible for meetings involving varied program elements, and attended by hundreds of people with widely diverse interests, to have singleness of character, then the following can be said safely about three recent meetings of importance. . . .

One would say that the Lake Placid national meeting of the Institute was decidedly on the "where do we go from here" theme, both in the meeting auditorium and in the adjoining halls.

On the other hand, the Galveston one-day meeting of the South Texas local section typified what happens when a sizeable group of people from a vigorous, rapid-growth industrial area get together, eager to learn and apply new techniques.

The New York one-day meeting sponsored by the N. Y. local section endeavored—and succeeded—in presenting another cost estimation and technical methodology session, similar to those of the past which have built such an impressive reputation.

To all three of these meetings people came from great distances. For example, at the New York meeting there was a man who flew from Texas—and back again—only to attend the day's sessions.

If one might say that the New York meeting concentrated more on techniques than did the others, then it would also be true to point out the highly contemplative nature of the Lake Placid meeting of the Institute.

Being a resort meeting frankly intended to get people hundreds of miles away from their normal environmental interruptive factors, the Lake Placid meeting succeeded in doing just that. In addition, it attracted, and was attended by, literally hundreds of people in places of high responsibility in industry, business and the government. Education was properly represented, but the timing coincided so closely with opening of the universities and colleges, that most of the staff members present had only a day or so before having to rush back to their posts.

Impressive was the seriousness with which so many of these able people put themselves to the task of planning the future of chemical engineering—and its impact on the other disciplines, on business, and on industry.

The concern as to the professional standards of the chemical engineer culminated in final council action, reported elsewhere in this issue, entailing release of the document stating the Institute's position and recommendations to the individual Ch.E.

Where we will be by 1975 was soberly predicted, and served as the subject for a good deal of discussion away from the meeting hall. Reason: the leaders running things in 1975 are being trained now, or will be among the trainees of the near future. Question: are they being properly equipped for the problems ahead?

One cannot comprehend what our advanced status in 1975 may really be like without exercising a good deal of flexibility of attitude towards the existing relationships between primary, secondary and university education, and the role of industry in providing advanced training.

A particularly interesting fact, noted among those of vigorous activity in these discussions at Lake Placid, was that so many of the older, more maturely "established" men were exerting strong support towards recognition of the somewhat radical changes which seem to be coming along.

Another important facet of the Lake Placid meeting was that which brought to the chemical engineer a type of information not ordinarily made directly available in such quantity and quality. This refers to the explanations of the growth of chemical and petroleum companies by integration, estimates as to what nuclear fuel reprocessing will cost, and what the insuring of nuclear installations will involve. These and many other aspects of the program comprise papers appearing in current and future issues of C.E.P.

One of the major symposia at Galveston had to do with operations research. Another was on air and stream pollution. Both of these subjects are of importance to the particular type of industrial operations employed by the chemical process industries of the Southwest. One of the O.R. papers appears in this issue of C.E.P. and other papers from this meeting will be coming along shortly.

The Galveston meeting had an attendance of 716, which makes it truly a big meeting. 17 papers and 29 industrial exhibits in an environment of a "sunny fall day" tops off the vital statistics.

The New York meeting symposium on costs attracted such an overflowing number during the morning session, that standees spilled over into the hall. To correct this, a show of hands was taken during the luncheon (see candid picture) which indicated the desirability of moving to a much larger room for the afternoon. By 2:30 this room too was filled to the doors.

The cost estimation papers from this meeting are of such practical interest, that they will be published in C.E.P.—a good many of them in a special issue on this subject, in May 1956.

Papers on chemical treatment and hydrogen treatment of petroleum stocks made up another major symposium at the New York meeting.

These three meetings have, according

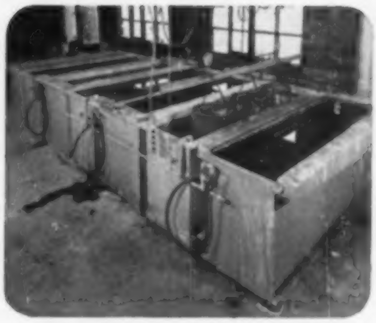
(*Concluded on page* 60)
(*Pictures on page* 58)

Here are five ways to use *versatile-flexible*

TYGON PLASTICS

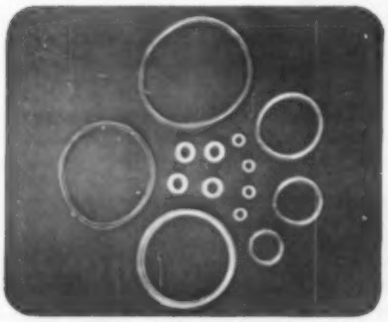
AS TUBING OR HOSE to pipe taste-sensitive liquid foods or corrosive chemicals. Tygon Tubing is glass-clear, flexible as a piece of string, resistant to acids and alkalies, non-toxic, sterilizable, and is made in bores from 1/16" to 2".

AS A PAINT to protect plant and equipment from attack by corrosive fumes and gases. Applied by brush or spray, Tygon air dries quickly to form a tough impermeable plastic skin that shrugs off acids, alkalies, oils, water and alcohols.



AS A HEAVY-DUTY LINING to protect the interior of pickling, plating, chemical processing and storage tanks from destruction by corrosive solutions. Easier to install than rubber linings, Tygon can be applied to tanks of any size or shape.

AS A CORROSION-RESISTANT GASKETING. Tygon shows no chemical deterioration with age. Gaskets remain flexible and tight, unaffected by weather or exposure to chemicals. Tygon gaskets are available in an almost unlimited size range.



AS MOLDED ITEMS. Tygon's toughness, durability and flexibility, coupled with staunch chemical resistance, offer pronounced performance characteristics for grommets, washers and molded mechanical goods items in virtually any shape.

Tygon is but one of a number of specialized materials manufactured and fabricated by The United States Stoneware Company or its affiliated divisions. Other products include: chemical ceramics, in stoneware or porcelain; sintered metallic oxides; natural, neoprene, silicone or other synthetic rubbers; acid brick and cements; adhesives and organic bonding agents, and specialized processing equipment.

VISIT BOOTHS 10-12-14
EXPOSITION OF CHEMICAL INDUSTRIES
PHILADELPHIA - DEC. 5-9

WRITE TODAY for the TYGON PORTFOLIO. *Pertinent data and technical characteristics of the various Tygon compounds to enable you to determine just how you can use Tygon most advantageously. Free, on request. Address Dept. CEP 1155.*

U. S. STONEWARE

PLASTICS and SYNTHETICS DIVISION

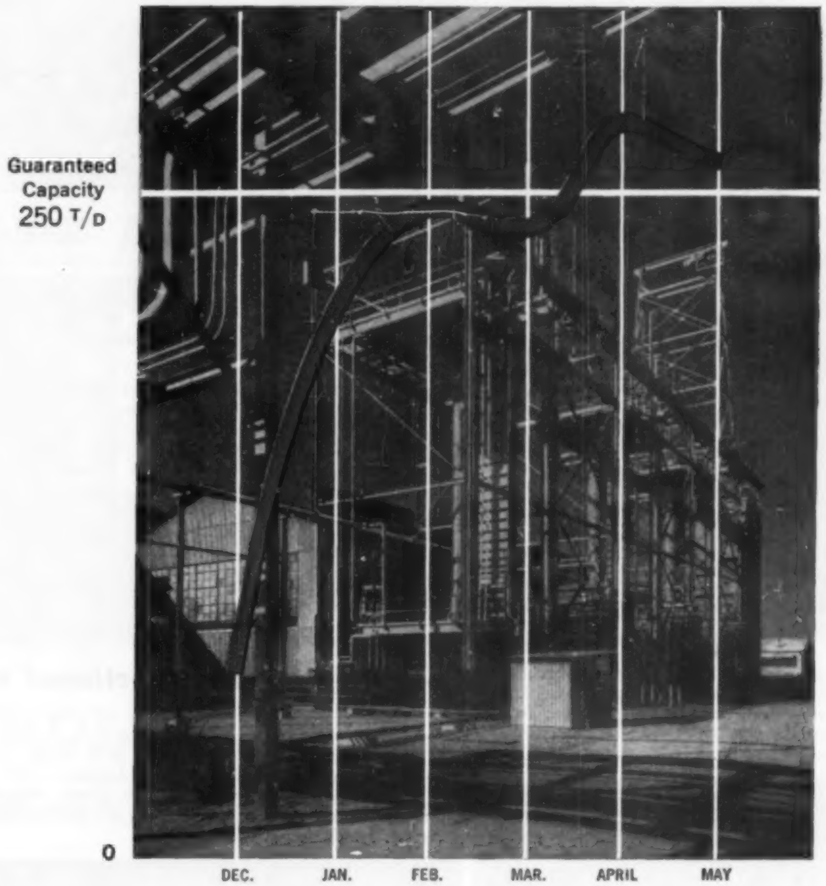
Akron 9, Ohio

497-D

AMMONIA PRODUCTION AT GRACE CHEMICAL

goes "OVER THE TOP"

with exclusive FW Sequence



The above curve shows average monthly output of liquid anhydrous ammonia at the new Grace Chemical Company plant in Memphis, Tenn.

From "on stream" to full capacity production, on the basis of monthly averages, was achieved within 3½ months—a short period of time for a completely new plant. On a *daily* basis, full production was actually exceeded within 30 days from start-up. And the average monthly production, 90 days later, was *well above* the rated plant capacity.

This demonstrates the ease and rapidity with which the FW sequence for ammonia synthesis can be put on stream and raised to full production capacity, and proves the efficient functioning of all elements of the system—Texaco partial oxidation, FW liquid nitrogen wash and Casale ammonia synthesis.

For complete information on this Grace plant installation, send for the Mar.-April 1955 issue of "Heat Engineering." *Foster Wheeler Corporation, 165 Broadway, New York 6, N. Y.*

FOSTER WHEELER

NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT.

CANDID PICTURES FROM

LAKE PLACID

l. to r., Dean J. C. Elgin giving paper on "Educating the Ch.E. of the future"; "Social competence" symposium: J. Donovan (ch.), Major General W. M. Creasy, H. W. Page, W. R. Collings, & R. K. Gottshall; "Atoms for Profit" symposium: L. E. Brownell, B. V. Coplan, J. K. Davidson, W. K. Davis (ch.), M. M. Braidech, & G. White.

(2nd row) Mrs. W. H. Mohrhoff in ladies putting contest; L. J. Coulthurst (tech. program ch.) at banquet, with H. F. Smiddy (banquet speaker) & F. J. Van Antwerpen seated; C. E. Reed; "Chemical Engrg. Organizations of the Future" symposium group: C. R. McCullough, G. T. Hunter (for C. R. DeCarlo), J. F. Thornton (ch.), J. C. Elgin, & B. K. Brown.

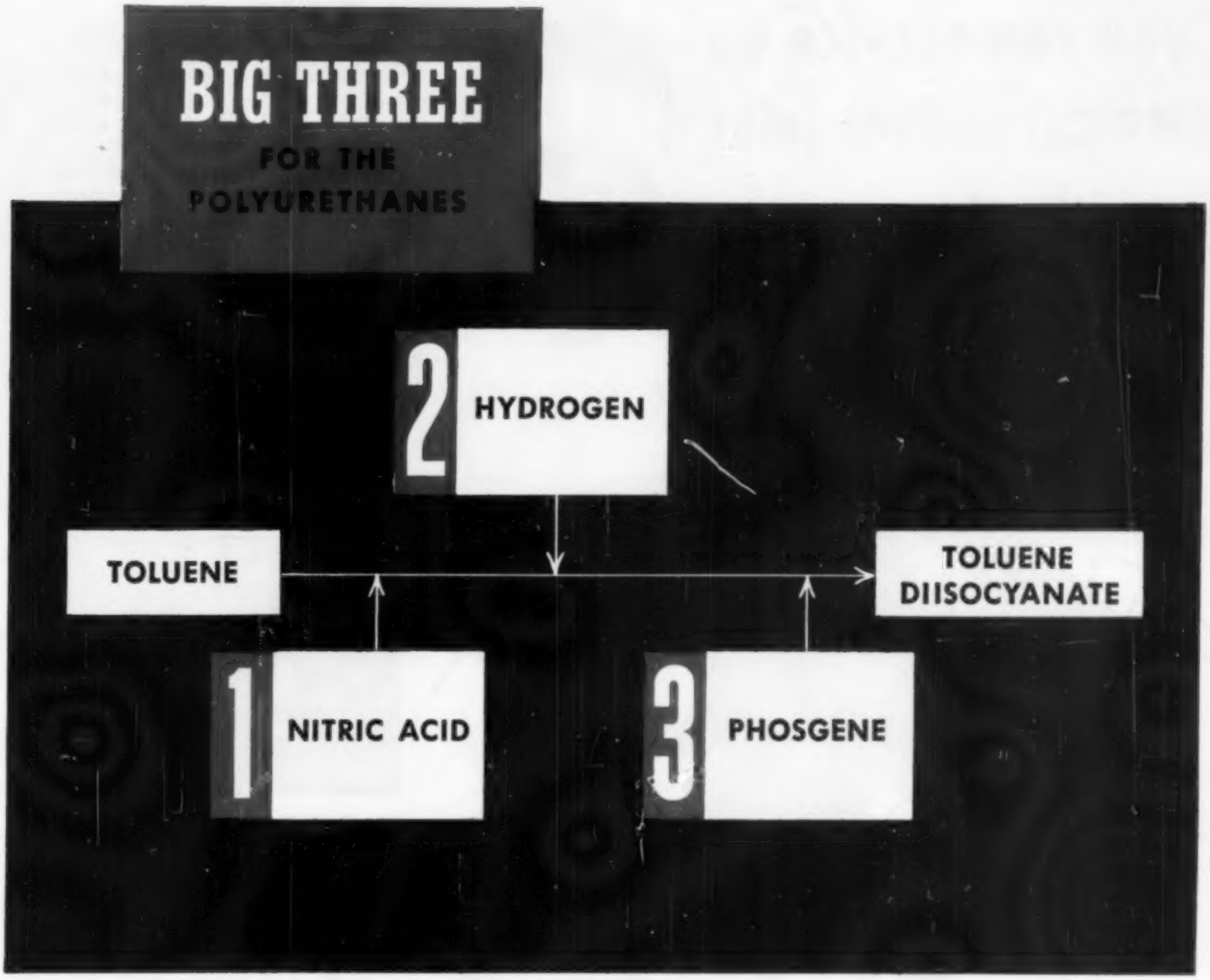
(3rd row) Press room: Don Waterfield, W. J. Farrisee, W. S. Frank, J. D. Snyder, J. T. Castles (ch.), & Mrs. Ronald Butler. Group watching turbine demonstration (Oct. C.E.P.). At trophies dinner: S. L. Lopata, Mrs. Jenkins, G. F. Jenkins, Mrs. E. J. Lyons, J. J. Healy, & Mrs. C. L. Knowles.

(bottom) Tennis; Banquet scene, with Mrs. F. J. Van Antwerpen and Mrs. C. G. Kirkbride in foreground. "Growth by Integration" symposium: W. R. Huber (for S. A. Swensrud), J. J. McLean, F. M. Simpson (ch.), R. B. Schneider, W. P. Gage.

—and two recent sectional affairs

▼ **Galveston**—The South Texas section's E. W. Bowerman (publicity chairman) provided these pictures, which show vividly the magnitude as well as the spirit of a very lively meeting. In one picture, a "Hero—model chairman" award to Bill Bolles (general chairman) is presented by Guy McBride (chairman, So. Texas section).

▼ **New York**—l. to r.: A. L. Regnier, G. P. Monet, T. B. Drew, B. H. Rosen. Cost symposium. (center) T. M. Jackson, Jr. (ch. sympos. comm.) & C. H. Chilton (ch. N. Y. sect.) H. W. Zabel. Another session. (Bottom) H. Walker, H. G. McGrath, W. W. Scheumann, J. McAfee, M. Sittig. "Hands up" at luncheon.


BIG THREE
FOR THE
POLYURETHANES
2
HYDROGEN
TOLUENE
TOLUENE
DIISOCYANATE
1
NITRIC ACID
3
PHOSGENE

MEETINGS

(*Continued from page* 54)

to their specific objectives, opened the way for further major advances in chemical engineering. In the case of this particular three, the range of their scope is so extreme as to be of noteworthy, perhaps even sober, consideration by members of the profession.

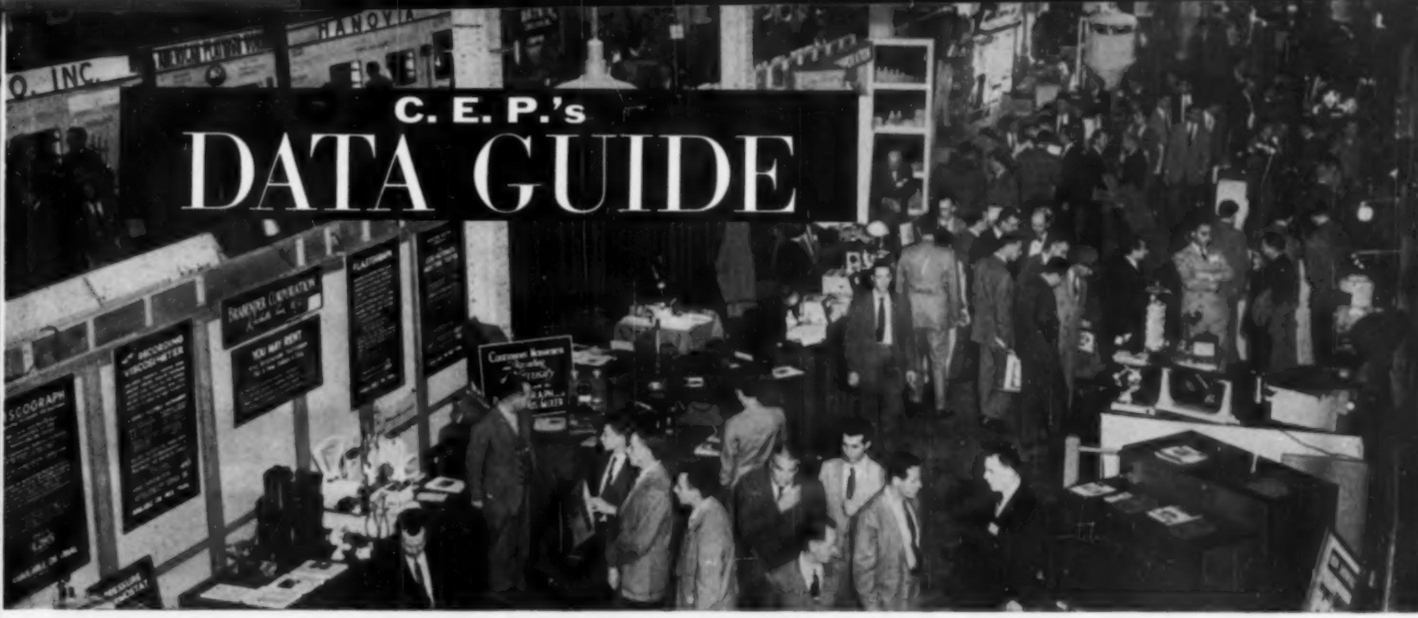
It is indeed heartening to note that we are consciously aware of our profession's needs and responsibilities, ranging all the way from protection of our communities from pollution, to protection of our individuals from non-professional standards.

THOSE TO WHOM CREDIT IS DUE FOR MEETING ARRANGEMENTS . . .

Lake Placid—Mrs. J. A. Consiglio (Ladies), J. G. Krieble (Printing), J. A. Consiglio (Registration), L. J. Coulthurst (Tech. Program), Mrs. J. D. Snyder (Ladies), J. D. Snyder (co-secretary), Mrs. J. T. Castles (Ladies), J. T. Castles (Public Relations), R. B. Rice (Hotel & Transportation), R. H. Simon (general chairman), Mrs. R. H. Simon (Ladies), R. F. Heitzman, L. S. Coonley (Local Trips), Mrs. J. O. Hougen (Ladies), Mrs. R. F. Heitzman (Ladies), J. O. Hougen.

Galveston—P. W. Eatman (Exhibits), T. Dougherty (Registration), F. Kunreuther (Program), W. H. Stanton (vice chairman), R. F. Stahl (Arrangements), E. W. Bowerman (Publicity), W. L. Bolles (general chairman).

New York—A group picture of persons responsible for the 1955 one-day meeting not being available, their names are listed for acknowledgments: T. M. Jackson, Jr. (chairman); John Happel, H. G. McGrath, & T. B. Drew (co-chairmen); T. B. Richey (Finance); John Colton (Arrangements); R. F. Fremed (Publicity); H. Y. Krinsky (Registration).



C. E. P.'s DATA GUIDE

to the 25TH EXPOSITION *of* CHEMICAL INDUSTRIES

Philadelphia, Pa.—December 5-9, 1955

featuring

The Philadelphia "Chem Show" represents the world's largest display of processing equipment, materials, and accessories. Many suppliers launch new product models at this bi-annual affair. Of additional interest to engineers is the full-scale equipment, displayed for one week and then sent to its purchasers for installation. In this special section, C.E.P. endeavors to present a *chemical engineer's* guide to these exhibits, to serve both those who visit and those who will not have the opportunity to do so.

products to be exhibited

names of technical representatives whom you can consult

data available in booklets, catalogs, etc.

DATA-BY-MAIL

Available conveniently through C.E.P.'s DATA SERVICE—merely encircle appropriate D.S., numbers on post cards in stiff cardboard insert, for the product literature to be sent to you by mail. . .

Ace Glass, Inc., Vineland, N. J. Booth 710
D.S. 1—Sintered Glass Filters—First laboratory glassware.
Bulletins: 50-p. catalog supplement.
Personnel: *Albert H. Klein, Sales Manager; Charles DeWoody, res. dir.; Gene Ret, sales rep., Walter Hogue, sales rep.*

Ackerman, Harold P., Upper Darby, Pa. Booth 824
See—Toledo Porcelain Enamel Products Co.; Mudco, Inc.

Adams Co., Inc., R. P., Buffalo, N. Y. Booth 410
D.S. 2—Porous stone and porous carbon filters for liquids & molten solids. Porous stone air-filter. Aftercoolers for compressed air service.
Bulletins: 12-p. chemical filters explains operation & uses. 8-p. air filters includes selection charts. 12-p. aftercoolers.
Personnel: *R. P. Adams, pres.; L. M. Rawlings, sales mgr.; sales engrs.—D. F. Anspach, R. Deverell, J. J. Murtagh, J. Sacha.*

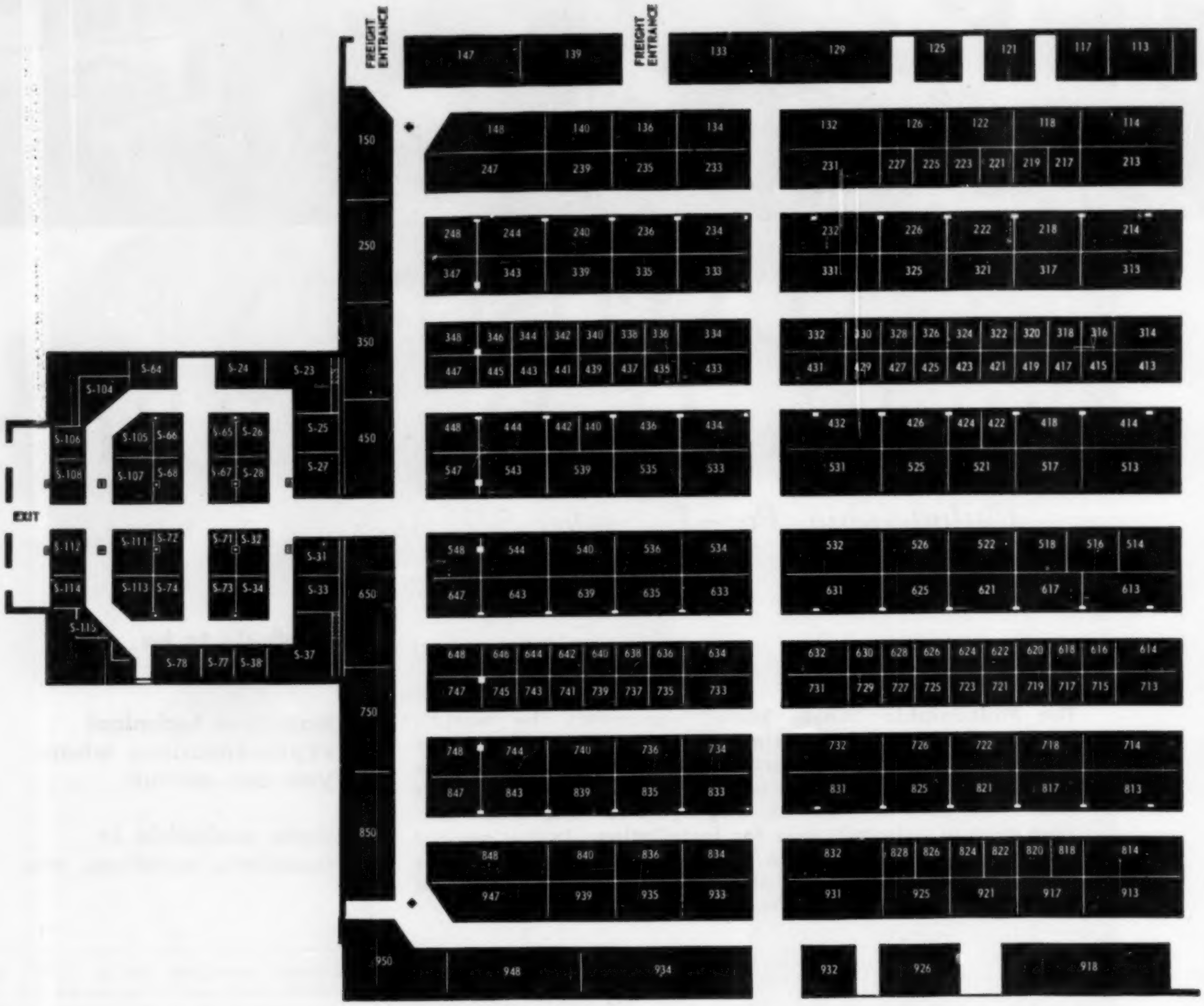
Aetna Scientific Co., Everett, Mass. Booth 221
D.S. 3—Laboratory Water Stills, Sterilizers, Autoclaves.
Bulletin: Complete catalog.
Personnel: *J. J. Panico, genl. mgr.; W. L. Putnam; Jack Lorenz.*

Airetool Mfg. Co., Springfield, Ohio. Booth 5-74
D.S. 3—Condenser Cleaner, internal tube cutter, tube expanders and cleaners.
Bulletins: 20 pp. tube cleaners & expanders, oil refinery specialties. Single data pages tube rolling control, internal tube cutter & condenser cleaner.
Personnel: *I. T. Thornson, sales mgr.; H. Russell.*

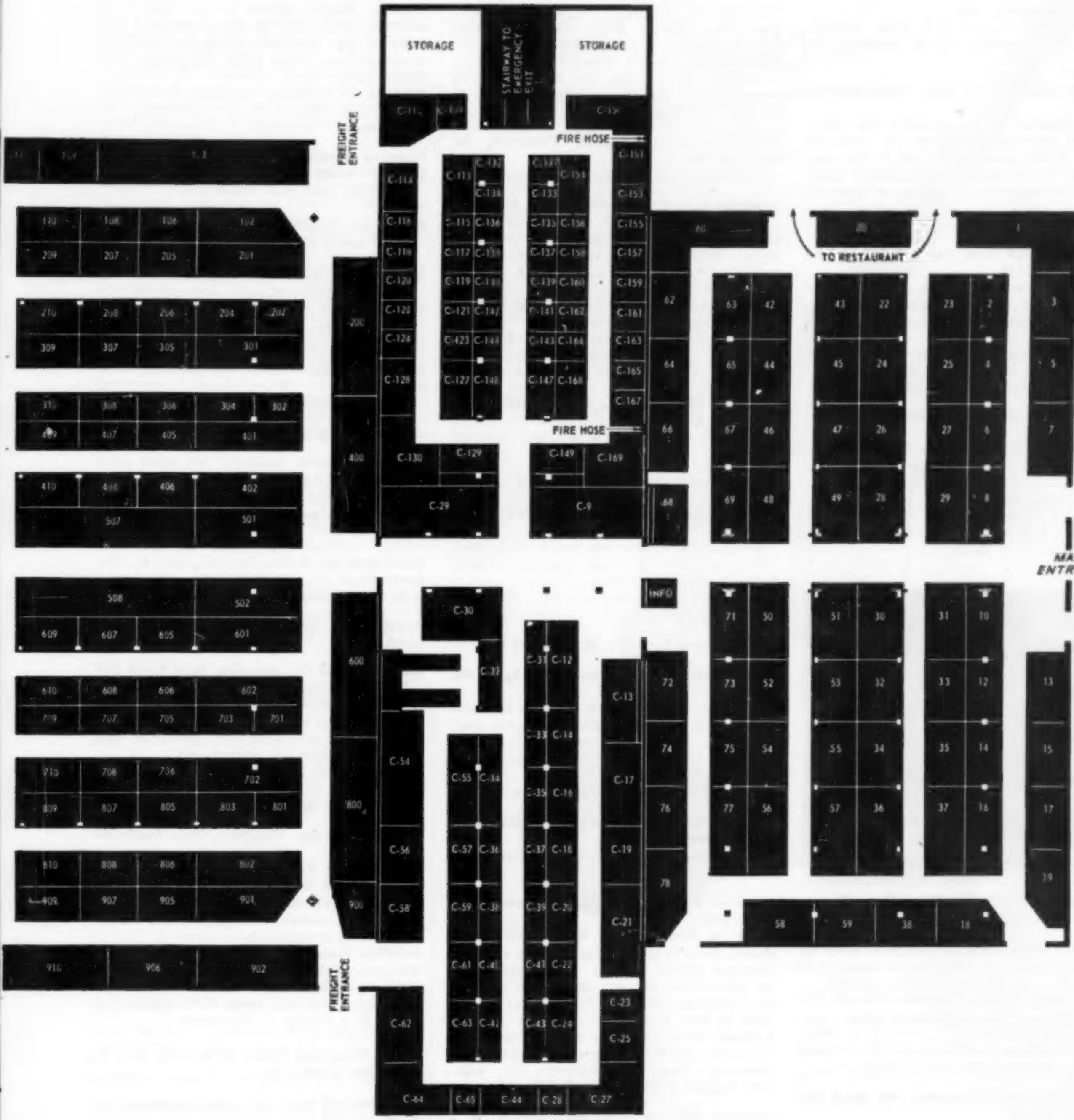
Alberene Stone Corp. of Va., New York City. Booth 533
D.S. 4—Laboratory table tops & sinks. Perchloric acid fume hoods.

(*Continued on page* 64)

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION



floor plans | COMMERCIAL MUSEUM and CONVENTION HALL



The Exposition of Chemical Industries will be held this year in Philadelphia, Pa., December 5-9 at the Commercial Museum and Convention Hall. The doors will open Monday, December 5, at 12 noon, then daily at 10 A. M. The Show will close at 10 P. M. on Monday and Thursday and at 6 P. M. on Tuesday, Wednesday and Friday.

The Museum is at 34th Street and Curie Avenue.

SPECIAL BUS SERVICE

As a convenience for those attending the Exposition special bus service will be provided. Buses will leave principal hotels at frequent intervals for Commercial Museum and Convention Hall. Round trip fare 50 cents, one way 35 cents. Look for sign in hotel lobby directing to boarding point.

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Bulletins: Laboratory; sink.
Personnel: J. L. Kretzner; H. S. Swift; J. H. C. Schmidt; W. E. Atkins; W. G. McKinney; A. Strauss.

Allegheny Ludlum Steel Corp., Pittsburgh, Pa. Booth 28
D.S. 5—Display of s.s. including the new—AM350, a hardenable Cr-Ni-Mo s.s. Also the 200, 201 & 202 grades. Both 201 & 202 were developed to use manganese instead of nickel & to assure ample future supplies of austenitic s.s.
Bulletins: 12-p. technical report on AM350.

Allen-Sherman-Hoff Pump Co., Wynnewood, Pa. Booth C-119—C-121
D.S. 6—Centriseal pump for corrosives and/or abrasives. Requires no gland seal water. Totally lined with easily replaceable rubber or synthetic parts.
Bulletins: Centriseal Pumps. Hydroseal Pumps.
Personnel: W. B. Stephenson, v. p. & genl. mgr.; F. S. Stow, chief engr.; D. G. Ashe; G. H. Stieff.

Allis-Chalmers Mfg. Co., Milwaukee, Wis. Booth 934
D.S. 7—A safety Diesel fork lift truck model FTDX. Design eliminates danger of fires & explosions. Also Buda engine, lifting jacks.
Bulletins: 4-pp. FTDX truck.
Personnel: L. S. Daniels, v. p.; C. L. Thompson, sales mgr.; H. A. McNaughton; H. H. Cohenour; John Scudder; C. A. Leetz.

Magnetrol Booth. See *D.S. 113*, p. 98.

Alloy Steel Products Co., Linden, N. J. Booth 35
D.S. 8—Display of gate, globe, check, Y & angle valves for corrosion-resisting service.
Bulletins: 8-p. general line; 8-p. Aloyco 20; 4-p. Monel & nickel; 4-p. Hastelloy alloys.
Personnel: R. M. Davis, v. p., sales; E. G. Holmberg, metallurgist; R. E. Boller, Jr.; H. V. Evans, Jr.; H. E. Johnson; R. M. Davis; Ralph Dale.

Allis Co., The Louis, Milwaukee, Wis. Booth 931
Electric motors.

Alpha Plastics, Inc., W. Orange, N. J. Booth 5-108
D.S. 9—Rigid PVC pipe and fittings ½ to 4 in. Also new, light wall pressure rated schedule of pipe.
Bulletins: 6-p. on properties, dimensions, corrosion resistance & installation instructions.
Personnel: C. E. Harkrader; J. S. Schaul, Jr.; C. W. Oswald.

Alsop Engrg. Corp., Milldale, Conn. Booth 124
D.S. 10—Sealed-Disc & Disc-Pak (cartridge type) clarifying filters in s.s. & other corros.-resis. mtls. Standard 50-gal. s.s. open mixing tank complete with ¼ h.p. mixer, etc.
Bulletins: 32-p. catalog of entire line.
Personnel: C. E. Crowley, pres. & sales mgr.; S. Alsop, exec. v. p.; W. W. Freystadt, v. p.; R. W. Fox.

Aluminum Co. of America, Pittsburgh, Pa. Booth 233-235
Corrosion resisting materials of construction.

American Agile Corp., Bedford, Ohio. Booth 817
D.S. 11—New fluidized powder unit for applying corros.-resist. coatings of polyethylene, nylon, polyfluoro carbons, etc.: polyethylene tanks to 100 gal. capacity, ducting & duct fittings, centrifugal fans. Lab. ware.
Bulletins: 12-p. Agilene general line detailed catalog, 12-p. ductwork data.
Personnel: J. A. Neumann, pres.; C. E. Freedman, exec. v. p.; R. F. Roth, mgr. sales & tech. serv.; F. J. Bockhoff, assoc. dir., res. & devel.

American Air Filter Co., Inc., Louisville, Ky. Booth 150 & 250
Filtration, electrostatic, & wet type dust collectors.

A. C. S., Washington, D. C. Booth 1

American Gas Furnace Co., Elizabeth, N. J. Booth 638
D.S. 12a—New type nat. gas & air burners. Photographic display of var. types gas furnaces.
Bulletins: Burners; furnaces.
Personnel: F. C. Schaefer, sales mgr.; F. Korzeb; H. J. Kempf; W. L. Tasker.

A.I.Ch.E., New York City, N. Y. Booth 828

American Instrument Co., Inc., Silver Spgs., Md. Booth 736
D.S. 12b—Small electronic humidity controller (Humistat) automatically operates large or small humidifiers & air conditioners to maintain humidity control within ±1.25% relative humidity.
Bulletins: 8-p. Humistat, selection data.

American Machine & Metals, Inc., E. Moline, Ill. Booth 802-806
(See Tolhurst Centrifugals & Niagara Filters Divs.)

American Plant Equip. Co., Elizabeth, N. J. Booth 5-65
D.S. 14—Pressure leaf filters with power sluicers for cake removal for use with automatic sequence control systems. Pilot model filter for determining filtration rates, cake densities, etc. Synthetic filtration fabrics plus various types of filter leaves.
Bulletins: HVP-55 features chap. on calculating filter area, cake & leaf spacing. Lists 64 models.
Personnel: Frank Mittelberger, filtr. engr., Fred Ruppert & Theodore Keith, sales engrs.

American Platinum Wks., Inc., Newark, N. J. Booth C-17-19-21
Rare metals ware, catalysts and chemicals.

American Tool & Machine Co., Boston, Mass. Booth 826
Basket centrifugals.

American Water Softener Co., Inc., Philadelphia. Booth 5-64

American Well Works, Aurora, Ill. Booth C-160
D.S. 15—Homomix motor driven pipeline mixer unit. Instant, continuous mixing within pipeline. Stages variable to suit number of additives, which may be liquid, gas, or slurry.
Bulletins: 4-p. Homomix operating principles, dimension data. Tech. Supp. 4-p. features exploded views.
Personnel: G. E. Hauer, v.p.-engrg.; C. A. Scott, v. p.; H. W. Hauser; E. M. Masterson; J. R. Grandinetti.

American Wheelbrator & Equip. Corp., Mishawaka, Ind. Booth 133
Filter-tube type dust connectors.

Amersil Co., Inc., Hillside, N. J. Booth C-17-19-21
Fused quartz pipe, ware.

Ampco Metal, Inc., Milwaukee, Wis. Booth 913
Special aluminum-bronze corrosion-resisting alloys available in forms for fabrication. Centrifugal pumps, valves, spun heads, bubble caps, etc.

Analytical Measurements, Inc., Chatham, N. J. Booth 443
D.S. 16—Showing a pH analytical pocket meter.
Personnel: F. G. Paully, pres.; K. J. Lesker, Jr., sales engr.

Anderson Co., The V. D., Cleveland, Ohio. Booth C-129
Centrifugal entrainment separators, steam traps.

Andrews-Knapp Constr. Co., Inc., Long Is. City. Booth 19
Su Knapp Mills, Inc.

Angel & Co., Inc., H. Reeve, New York City. Booth 725

Ansul Chemical Co., Marinette, Wisc. Booth 521
D.S. 17—Sodium bisulfate (tech. grade, pelletized), sulphur dioxide, methyl chloride, glycol dimethyl ether, hydroquinone ethers.
Bulletins: 24-p. glycol dimethyl ether; var. data sheets; 16-p. chemical products cat.
Personnel: F. W. Wedge, chem. prod. mgr.; R. E. Thompson; H. E. Arkens; J. R. Galloway; A. O. Wingender; A. B. Guise, dir. of res.

Armco Steel Corp., Middleton, Ohio. Booth 231

Artisan Metal Products, Inc., Waltham, Mass. Booth 318
D.S. 18—New distillation unit; single stage ejector with carbon liner; pilot model Kontro Ajust-O-Film process unit.
Bulletins: Process equipment brochure; Kontro brochure; Jet-Evactor cat. with specs. & other data; piping brochure.
Personnel: J. Donovan, treas.; C. W. Angell; L. J. Monty; K. J. Berrian; J. W. Conrad.

Assoc. Cooperage Indus. of America, Inc., St. Louis, Mo. Booth 818

Atlas Mineral Prod. Co., The, Mertztown, Pa. Booth 415-417
D.S. 19—Corros.-resistant materials of construction including cements, coatings, linings, rigid plastic structures & pipe.
Bulletins: indus. floors; corros.-resis. tank linings; corros.-resis. cement; protective coatings; rig. plastic struc. & pipe.
Personnel: E. Kirkpatrick, genl. sales mgr.; A. A. Boova; D. Weidner; G. F. Gilbert, Jr.

Atlas Powder Co., Wilmington, Del. Booths 302-302 & 401
(Chemicals Division)

Aurora Pump Co., Aurora, Ill. Booth 333-335
(See N. Y. Air Brake Co.)

Autoclave Engrs. Sales Corp., Newark, N. J. Booth 434

Automatic Switch Co., Orange, N. J. Booth 646
D.S. 20—Solenoid-operated valves, 2- and 3-way. Some in s.s. and other mat. for corrosive fluid control. A new sensitive electronic relay.
Bulletins: Data sheets on 2-way valves, various types; also 3-way valve.
Personnel: W. F. Hurlburt, Jr. pres.; R. Hurlburt, genl. mgr. & contr.; D. M. Darrin, v. p. & treas.; R. McCormick, valve sales mgr.; F. Spinelli, switch sales mgr.; R. Castenschoid; R. May; N. Fleno; D. Jarvis.

B-I-F Industries, Inc., Providence, R.I. Booth 902
(See Proportioneers, Inc.) Liquid proportioning pumps, flow-tubes for fluid flow metering.

Babcock & Wilcox Co., The, Beaver Falls, Pa. Booth 75
D.S. 21—Seamless & welded carbon alloy & s.s. tubing & pipe for all process industry applications. Seamless welding fittings & flanges.
Bulletins: 142-p-props. carbon & alloy seamless steel tubing; 48-p. methods of working seamless tubes & pipe of intermed. B. & W. croloys; FB-76-seamless welding fittings & flanges.
Personnel: W. H. Buley, mgr. s.s. sales; R. W. McAndrews, welding fittings; D. J. Petti, dist. sales mgr.; J. J. B. Rutherford, chf. metall.; J. S. Anderson, genl. sales mgr.; F. J. Corbett.

Bailey Meter Co., Cleveland, Ohio. Booth 30
D.S. 22—For the first time—D-C receiver-recorder for d-c telemetering systems in process industries; square-root pneu. transmitter for measuring & transmitting of flow from differential meas. elements; running-time recorder for record. periodic oper. time of a process; Bailey combustion analyzer for analysis of furnace gases for oxygen & combustible content. Also line of standard products.
Bulletins: 12-p. D-C recorder specs.; 6-p. on the square-root pneu. trans. specs.; 2-p. on running time recorder; 2-p. on the heat prover.
Personnel: H. M. Hammond, v. p.; W. E. Dueringer, asst. sales mgr.; F. H. Fellows; H. C. Tanner; D. W. Moyer.

Baird Assoc., Inc., Cambridge, Mass. Booth 63
Continuous Process stream analyzing spectrophotometer.

Baker & Co., Inc., Newark, New Jersey. Booth C-17-19-21
Precious metal catalysts, ware, & rupture discs.

Baker Perkins Inc., Saginaw, Mich. Booth 540-544
D.S. 23—Exhibition of—Baker Perkins Ko-Kneader continuous kneading-type mixer (list system); universal mixer; continuous and the universal centrifugals.
Bulletins: 16-p. on Ter Meer continuous centrifugals; 16-p. on solids-liquids mixing and separating process equipment.

Barco Mfg. Co., Barrington, Ill. Booth C-20
Ball joints for pipe lines.

Barneby-Cheney Co., Columbus, Ohio. Booth 17

Barnstead Still & Sterilizer Co., Boston, Mass. Booth 636
D.S. 24—Water distillation equipment.

Barrett-Cravens Co., Northbrook, Ill. Booth 634 & 733

Bart Mfg. Corp., Belleville, N. J. Booth 107
D.S. 25—Electro-plated nickel pipe, fittings, sheet & plate fabricated vessel equipment—plated to specs. by exclusive large-scale process; complete line of Sel-Rex double duty filters

(*Continued on page* 66)

for liquid clarification or solids recovery. Interchangeable s.s. mesh & porous stone filter elements. Cap. 250 to 18000 GPH.
Bulletins: 4-p. on Lectro-clad process for nickel-plating, includes welding instructions; 4-p. on Lectro-clad process for sheet steel; 4-p. on Sel-Rex filters.
Personnel: R. N. Griffin, v. p.; J. P. McNally, sales mgr.; J. Seme.

Bartlett & Snow Co., The C. O., Cleveland, O. Booth 247
D.S. 27—Comb. rotary calciner & cooler; steam heated rotary & batch dryers.
Personnel: R. Jooss, mgr.; M. C. Isheim, asst. mgr.; E. M. Polsak; A. V. Borkland; R. E. Orr; T. Repella; H. T. Somme.

Bean Div., John, Lansing, Mich. Booth 326
(See Food Mach. & Chem. Corp.)

Beaumont Birch Co., Phila., Pa. Booth 445
D.S. 28—Periphery-sealed rotary feeders for high pressure or vacuum feeding, plus a bucket elevator & conveyor chains.
Bulletins: On rotary feeders. Cites advantages, schematic drawings, data. Data sheets on chain.
Personnel: S. T. Transeau, mgr. chem. div.; N. M. McCloskey, chief engr. chem. div.

Beckman, Inc., A. O., So. Pasadena, Calif. Booth 643
D.S. 29—New oxygen analyzers for measuring flue gas, gas process streams, etc. employing thermal conductivity principle; dissolved oxygen analyzer; gas density balances for continuous or fixed meas. of gas streams.
Personnel: W. E. Dixon, sales mgr.; R. W. Negus, custom prod. supv.; S. Hazel; H. Bauer; J. McNamara.

Beckman Instruments, Inc., Fullerton, Calif. Booth 20
D.S. 30—Liston-Becker non-dispersive, continuous, process stream infrared gas analyzer & a Beckman dispersive, continuous, process stream infrared analyzer plus pH, color, titration & flame spectrophotometric devices.
Bulletins: 12-p. DK-2 ratio-recording spectrophotometer with curves, characteristics; 8-p. on complete line of recording spectrophotometers; IR-2A auto, infrared spectro.; flow colorimeter. Also spec. sheets.
Personnel: J. M. Manypenny, east. reg. mgr.; A. D. Herbert; G. Green; N. Weber; J. P. Addonizio; R. A. Lowe.

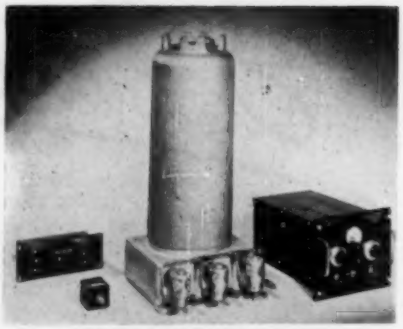
Bemis Bros. Bag Co., St. Louis. Mo. Booth 13
D.S. 31—Plastic, paper, cotton, burlap, & waterproof laminated textile bags. Molded cellulose products.
Personnel: A. B. Merriam, R. M. LeRoy, mgr. Techmold prod.; C. L. Ferguson, supv. waterproof sales; M. C. Barnes, packing serv.

Berger Mfg. Div., Canton, Ohio. Booth 535-539
(See Republic Steel Corp.)

Bethlehem Apparatus Co., Inc., Hellertown, Pa. Booth S-148
D.S. 32—Mercury cleaning apparatus; laboratory tools.
Bulletins: Mercury; Glassworking Manual.
Personnel: C. W. Nieman, pres.; J. B. Lawrence, v. p.; Mrs. J. B. Lawrence.

Biach Industries, Inc., Cranford, N. J. Booth C-131

Bird Machine Co., So. Walpole, Mass. Booth 321, 325
D.S. 33—Prayon filter—new & advanced design of contin. rotary horizontal bed vacuum filter with multi-stage washing, min. wash liquor. Humboldt screen type centrif. dryer; centrifugals.
Bulletins: 8-p. Prayon filter—details, cutaway views, sizes, application flowsheets, etc. 8-p. Humboldt centrifugal dryer extensive data.
Personnel: G. Sherrerd, v. p.; F. X. Ferney, asst. sales mgr.; E. G. Piper; C. A. King; H. H. Shepherd; B. D. Warren; J. J. Gillis; R. A. Bamford.



Liston-Becker Infra-Red Gas Analyzer. See D.S. 30, col. 1.

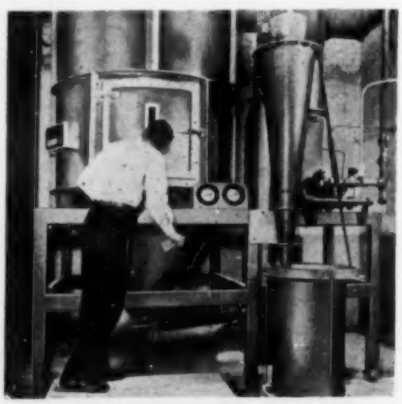
Bishop, J. & Co., Malvern, Pa. Booth 209
D.S. 34—Fabricated platinum & its alloys; Stainless tubing & fabr. tubular parts.
Bulletins: No. 11 in series of s.s., nickel & nickel alloy tubing & tubular fabr. parts.
Personnel: S. V. Whitaker, genl. sales mgr.; H. E. Love; D. E. Lundy; J. Branegan; J. M. Moran; P. C. Kehoe; C. R. Sweet; L. Moules.

Black Products Co., Chicago, Ill. Booth C-113

Black, Sivalls & Bryson, Inc., Kansas City, Mo. Booth 114
Regulating valves, liquid level controllers, pressure control pilots, safety bursting discs.

Blaw-Knox Co., Pittsburgh, Pa. Booth 103
Autoclaves vessels, quick opening doors, Electro-Vapor & Dowtherm heating systems, resin pilot plants. Also see Buflovak Equipment Div. Chemical Plants Div. offers processes.

Buflovak Equip. Div., Buffalo, N. Y. Booth 103
Evaporators, crystallizers, coolers, drum-dryers, rotary dryers, kettles, vacuum dryers, pilot plant equipment. Also see Blaw-Knox Co.



Semi-Works Spray Dryer. D.S. 36, col. 3.

Blickman, S., Inc., Weehawken, N. J. Booth 407
D.S. 35—Fabricated alloy process vessel equipment.

Bogue Elec. Mfg. Co., Paterson, N. J. Booth 421

Bolt & Nut Div., Cleveland, Ohio. Booth 535-539
(See Republic Steel Corp.)

Bowen Engrg., Inc., No. Branch, N. J. Booth 613
D.S. 36—Spray dryers in sizes ranging from commercial through pilot plant. New conical bottom lab. spray dryer will be introduced.
Bulletins: 4-p. Conical lab. spray dryer; photos & specs. 4-p. semi-works spray dryer with capacity chart, spec.
Personnel: R. T. Reeve, pres.; W. T. Powers; J. J. Quinn, Jr.; W. A. Bowen; D. W. Belcher, chf. engr.; F. W. Meyer, dir. res.

Brabender Corp., Rochelle Pk., N. J. Booth C-35

Brinkman & Co., C. A., Great Neck, N. Y. Booth C-36
D.S. 37—Laboratory weighing and other apparatus.
Personnel: C. A. Brinkmann; J. D. Brown; H. Apt; R. Kincherf; K. Peters.

Brookfield Engrg. Labs., Inc., Stoughton, Mass. Booth 424

Brooks Rotameter Co., Lansdale, Pa. Booth 606
D.S. 38—Full-view indicating rotameters; pneumatic transmitters; electronic alarms; purge meters; specific gravity testers.
Bulletins: 20-p. full-view rotameters; 8-p. purge meters; 8-p. lab. kits; 2-p. Sho-Rate "50" meters; 4-p. Mag/Nu/Matic transmitters; 2-p. Spee-Gee gravity testers.
Personnel: D. N. Brooks, pres.; N. S. Brooks, v. p.-oper.; J. T. Aldrich, Jr.; J. L. Friling, Jr.; A. R. Hughes; E. A. Harper.

Brown Fintube Co., Elyria, Ohio. Booth 948
Heat exchangers, heaters, finned tubing.

Buda Co., The, Harvey, Ill. Booth 934
(Div. Allis-Chalmers Co.)

Buffalo Meter Co., Buffalo, N. Y. Booth 442
Water & other liquid meters.

Builders-Providence, Inc., Providence, R. I. Booth 902
(See B-I-F Industries)

Callery Chemical Co., Callery, Pa. Booth C-59
D.S. 39—Liquid metal pumps, magnetic flowmeter, liquid metal pressure transmitters; plus chemicals; boron compounds, Na-K alloys, etc.
Personnel: C. H. Staub, asst. to v. p.; C. B. Jackson, dir. res.; W. H. Schechter, proj. dir.; D. L. Chamberlain, new prods. supv.; D. J. Wain, sales engr.

Cambridge Inst. Co., Inc., New York, N. Y. Booth 926

Cambridge Wire Cloth Co., The, Cambridge, Md. Booth 214
D.S. 40—Woven wire conveyor belts; industrial wire cloth; special metal fabrications; gripper woven wire slings.

Carboline Co., St. Louis, Mo. Booth 628
Corrosion-resisting organic coatings for process vessel equipment, etc.

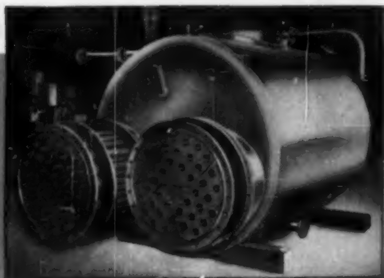
(Continued on page 74)

VERSATILITY

√ DESIGN

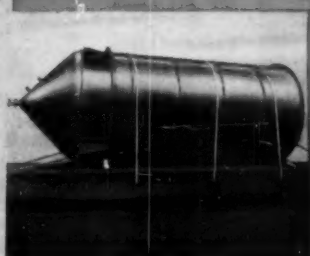
√ ENGINEERING

√ FABRICATION

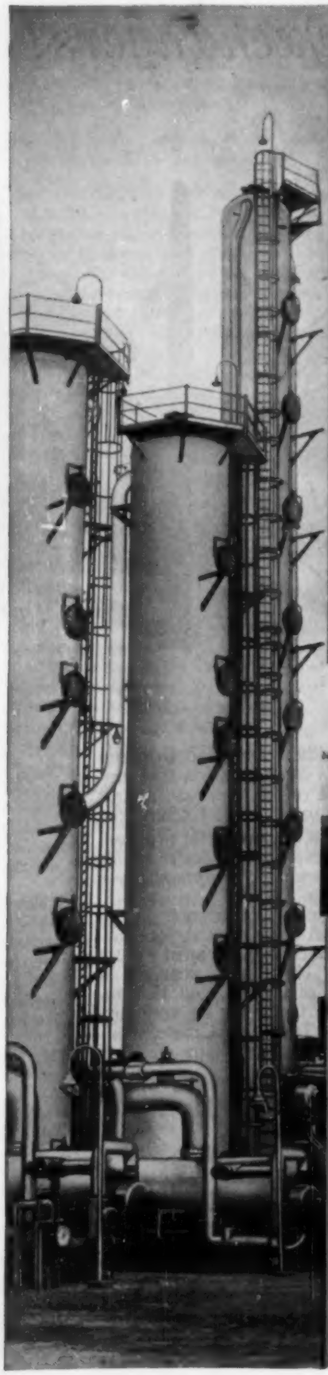


COPPER
Reboiler, with 2 Removable Bundles

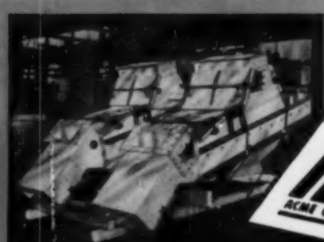
ALUMINUM
Storage Tank, 12'-0" Diameter by 50'-0" Long



MONEL
Tar Base Extraction Tank, 10'-0" Diameter 25'-7" High



STEEL
Distillation Columns



STAINLESS STEEL
Double Hummer Screen, Special Design

The advantage of working with one versatile source of equipment has been recognized by leaders in the process industries. A high degree of flexibility can more effectively correlate new equipment with existing facilities.

The equipment illustrated here demonstrates Acme versatility, proved through past performance in all processes.

From pilot plant to full scale operation . . . from drawing board to actual installation, Acme is pre-eminently equipped to serve the diverse needs of the process industries.

ACME
Processing Equipment
ACME COPPERSMITHING & MACHINE CO., ORELAND, PA.

DESIGN AND FABRICATION IN ALL FERROUS AND NON-FERROUS METALS.

Postage Will Be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD

First Class Permit No. 48890, Sec. 34.9, P. L. & R., New York, N. Y.

CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

No Postage Will Be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD

First Class Permit No. 48890, Sec. 34.9, P. L. & R., New York, N. Y.

CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

the chemical engineers'

DATA SERVICE

and

GUIDE

to significant developments in

- **EQUIPMENT**
- **MATERIALS**
- **SERVICES**

TO OBTAIN HELPFUL PRODUCT LITERATURE BY MAIL

SIMPLY SELECT ITEMS DESCRIBED BELOW OR IN SPECIAL CHEMICAL EXPOSITION SECTION (PAGES 61-118), THEN ENCIRCLE "D.S." CODE NUMBERS ON ONE OF THE CARDS AT LEFT.

products- (Advt. in this issue)

IFC Ethylene Glycol. For use in combination with pentaerythritol in making paints, & other surface coatings. Also for use as a solvent & a humectant. Carbide & Carbon Chemicals Co.

3R Rotary Sifter. A unit in operation will be shown at the Chem Show. See it if your process includes separation of dry materials. B. F. Gump Co.

4, 5A I-R Process Equipment. These compressors of various types & capacities put the pressure on ammonia production. Ingersoll-Rand Co.

6A Filtration. Improved design of the R. P. Adams Co., Inc. filters breaks bottlenecks, with longer runs & less maintenance.

8L Oil Reclaimer. Hilco provides a simple, economical & efficient method of restoring contaminated lubricating & sealing oil. The Hilliard Corp.

TURN THIS PAGE TO RIGHT FOR MORE . . .

HOW TO USE THIS POST CARD FOLDER

Merely encircle numbers on cards to get literature desired. On advertised products in front of magazine, fold this page out to right. For those in back, fold card strip again to right, where card strip is scored for detaching.

products-(Cont.)

9A Plants. Specialists in the design & erection of fertilizer, ammonium nitrate solutions & solids plants. Chemical and Industrial Corp.

10L Chemiseal. Every expansion joint tested for pressure. Protect the piping which they connect. United States Gasket Co.

11A Vertical Pulverizer. Unit has a built-in air classifier for increased production. May be shifted from one grinding size to another. Metals Disintegrating Co., Inc.

12, 13A Catalysts. Houdry Process Corp. now has available a line of alumina & other special base catalysts manufactured by their Chemicals Division.

14A Chempump. New double-ended unit shown at the Chem Show. Essentially two leakproof pumps in one. For unusually high head or high volume applications. Chempump Corp.

15A Liquid-Liquid Extractors. Now a newly designed extraction column which permits the use of solutions carrying suspended solids. York Process Equipment Corp.

16A Filters. Double-action principle of Staynew pipe line filters assures sustained, trouble-free operation at high load factors. Dollinger Corp.

17A Mechanipak Seals. A one-piece assembly, preset at the factory, which is easily installed, for use on process pumps. Garlock Packing Co.

18L Gages, Valves, Specialties. Units for use in the chemical & petrochemical processing industry. Available in a variety of materials & linings. Jerguson Gage & Valve Co.

19A Demisters. Yorkmesh demisters for use in vacuum towers, absorbers, scrubbers. Of Monel, nickel, 304-316-430 stainless steels, & other materials. Otto H. York Co., Inc.

20A Valves. Corrosion-resistant valves for process industries. Gate valves have unique split-wedge construction. Check valves feature non-slamming design. Crane Co.

21A Filters. Featured is a filter of high submergence type for use with precoating material. 316 stainless steel drum with ¼ in. thick PVC lining. Eimco Corp.

22, 23A Porcelain. Lapp porcelain for use in any process where liquids & gases must be tower-processed. Assure non-corrosion & purity of product. Lapp Insulator Co., Inc.

Pulsafeeder. A piston-diaphragm controlled-volume pump, also a Microflo unit for precision pumping at micro flow rates. Lapp Insulator Co., Inc.

24L Valves. Visible shutoff valves, custom-crafted, for severe applications. May be opened by one man in a minute. Hamer Valves, Inc.

25A Ammonia Plants. Designers of anhydrous ammonia plants to produce up to 900 tons/day. Consult Chemical Construction Corp.

26A Glassed Steel. At the Chem Show Pfaudler Co. will debut several new achievements in the field. Visit their booth.

27A Pumps, Valves, Heat Exchangers. Many new units in the Durco line will be shown at the Chem Show exhibit. Duriron Co., Inc.

28L Mixer. The unique shape of the mixer bowl presents a greater ratio of heated surface to mix. Capacities to 750 gal. Read Standard Corp.

29A GLC Anodes. Ample evidence of the importance of these anodes reflected by the experience of major chlor-alkali producers. Great Lakes Carbon Corp.

30A Flowmeter. If precise flow measurement is critical investigate Potter Aeronautical Co. turbine type units.

31A Ammonia Processes. Four different types for optimum efficiency developed. If product improvement or diversification are planned consult M. W. Kellogg Co.

32A Conveyor-Elevators. S-A Redler units may be the answer to your bulk handling problems. Include sealed conveying in any direction without contamination. Stephens-Adamson Mfg. Co.

33A Karbate. Equipment fabricated from this impervious graphite for rigid service in process industry. Note the ten pay-off features. National Carbon Co.

34L Catalysts. OXO process said to increase output 25%. Technical service available for consultation. Girdler Co.

35A Crystallizers. Experienced engineers will cooperate with you on your crystallization problems. Units of all types available. Struthers Wells Corp.

36A Dryers. New P-4 construction, improved housing panels, air distribution & control, plus super-power fans feature these conveyor dryers. National Drying Machinery Co.

37A Tubular Products. Operating difficulties due to corrosion, oxidation, pressures & temperatures often avoided using Babcock & Wilcox Co. stainless steel tubing.

38A Dryers. Product uniformity & drying per pound are two important factors. Proctor dryers provide these & many other features. Proctor & Schwartz, Inc.

39R Tubular Filters. Important new features due to flow from inside of tube. Simplified operation, no unfiltered heel. Industrial Filter & Pump Mfg. Co.

40L Filter Cloth. Metallic filter cloth allows only filtrate to pass through, is reversible with both sides identical. Available in weaves of all malleable metals. Newark Wire Cloth Co.

41A Air Preheater. You can increase each of your unit's output up to 25% using the Ljungstrom to recover waste heat. Air Preheater Corp.

42A Steel Belt Cooler. Unit carries material on a solid, endless, steel band of flat stainless or carbon steel. Sandvik Steel, Inc.

43A U. S. Varidrives. Three features of this motor are autostat tension control, double-ribbed belt & sliding spline. U. S. Electrical Motors, Inc.

44L Diaphragm Valves. Design eliminates normal worries. Choice of 15 diaphragm materials. Size range ⅜ in. through 14 in. Hills-McCanna Co.

45A Mixers. This process equipment on display at the Chem Show is designed & built for maximum efficiency. See it. Baker Perkins Inc.

46A Oxygen Plants. Designing & building of large capacity tonnage generators regardless of conditions is the special concern of Air Products, Inc.

48A Dowtherm. Greatest advantage in using Dowtherm is response to control at temperatures to 750° F. Ask for Dowtherm Handbook, a technical guide on the subject. Dow Chemical Co.

55A Tygon Plastics. Material is versatile & flexible. Use it as tubing or hose, paint, heavy-duty lining, & other ways. U. S. Stoneware Co.

56A Fittings. Corrosion-resistant valves, fittings, & pumps will be featured in the Chem Show display of Cooper Alloy Corp. Visit them to see how advanced know-how improves products.

57A Ammonia. Plant illustrated has exclusive FW sequence guaranteeing production of 250 ton/day. Information available. Foster Wheeler Corp.

59A Processing. Design, building, operating of process plants, materials, & apparatus is the business of Girdler Co.

60L Swivel Joints. Easy to inspect & service. Simply break the Emsco as you would a pipe union. Popular sizes for all types of service. Emsco Mfg. Co.

65R Process Equipment. A design & fabrication service based on long experience in the field. Badger Mfg. Co.

67A Heat Exchangers. Features are reduction in operating & unit costs. For temperatures as low as −300° F. In nitrogen production & hydrogen purification, Trane Co.

68A Process Equipment. From drawing board to actual installation Acme Coppersmithing & Machine Co. is equipped to supply your needs.

73A Spray Dryer. A conical lab. spray dryer with interchangeable nozzle or wheel atomization. Capacity 15 to 80 lb./hr. Bowen Engineering, Inc.

75A Heat Exchangers. Specially designed units meet exacting needs of the petroleum, chemical & petrochemical industries. Doyle & Roth Mfg. Co., Inc.

77A Calciner & Cooler. Permits continuous processing of materials from 900 to 2100° F. in a reducing, oxidizing or neutral atmosphere, cooled & discharged at 200° F. or lower. C. O. Bartlett-Snow Co.

78L Expansion Joints. ASME approved & stamped high flexibility joints for shell & fixed tube heat exchangers. Flexibility to ±3 in. of lateral expansion. Richard M. Armstrong Co.

79A Nickel Alloy. A new answer to corrosion & erosion-iron modified 90:10 with cupro-nickel alloy. Available in sheet & plate, pipe & tubing. International Nickel Co., Inc.

80L Coolers. Built by Downingtown Iron Works, Inc. from Ampco 8 coolers saved 25% of equipment costs. Information available on correct design & fabrication.

81A Filters. A call at booth C-54 will show you the newest developments in Sparkler filters in operation. Sparkler Mfg. Co.

82L Oxygen Analyzers. The G2 features many ranges but each unit may be supplied with two or more ranges. File data available. Arnold O. Beckman, Inc.

83A Valves. Tube Line valves up to 4,000 lb./sq.in. eliminate pipe threading may be installed in 3 easy steps. Autoclave Engineers, Inc.

84L Ball & Pebble Mills. The answers to questions on operation of these mills may be found in a Hand Book on the subject. Paul O. Abbe, Inc.

85A Haveg. A molded, rigid plastic material for fabrication of parts or equipment used under highly corrosive conditions. Haveg Corp.

86L Rotojet. A cleaner for tubes of all sizes & shapes. Roto heads & other parts available from stock. Elliott Co.

87A Process Equipment. F. J. Stokes Machine Co. makes its experience available to manufacturers through its well-staffed laboratory & advisory service. Production problems covered in a special bulletin.

89A Cooling Towers. Full-scale tests resulting in records shown prove the efficiency of Marley Co. towers.

90L Horizontal Pumps. Fabrication of these units from carefully selected materials meets the need for resistance to corrosive & abrasive actions of pumped fluid. Lawrence Pumps Inc.

91A Pipe Insulation. Unibestos said to increase insulating capacity, durability, & ease of installation. Sections to fit pipes through 44 in. O.D. Union Asbestos & Rubber Co.

92L 25th Exposition. 500-fact filled exhibits of the newest developments in the chemical & process industries. Chemical Industries Exposition.

Numbers without letters indicate data available as described in Data Service "Briefs." Numbers with letters refer to further data concerning products advertised in this issue. Letters indicate position of advertisement on page (if more than one on a page)—L, left; R, right; T, top; B, bottom; A indicates full page; IFC, IBC, and OBC are cover advertisements.

Please do not use this card after February, 1956

Use the following numbers for data-literature from the Chemical Exposition:

**1 2 3a 3b 4 5 6 7 8 9 10 11 12a 12b
14 15 16 17 18 19 20 21 22 23 24 25 26 27
28 29 30 31 32 33 34 35 36 37 38 39 40 41a
41b 42 43 44 45 46 47 48 49 50 51 52 53 54a
54b 55 56 57 58 59 60 61 62 63 64 65 66 67
68 69 70 71 72 73 74 75 76 77 78 79 80 81
82 83 84 85 86 87 88 89 90 91 92 93 94 95
96a 96b 97 98 99 100 101 102 103 104 105 106 107 108
109 110 111 112 114 115 116 117 118 119 120 121 122 123
124 125 126 127 128 129 130 131 132 133 134 135 136 137
138 139 140 141 142 143 144 145 146 147 148 149 150 151
152 153 154 155 156 157 158 159 160 161 162 163 164 165
166 167 168 169 170 171 172 173 174 175 176 177 178 179
180a 180b 180c 181 182 183 184 185 186 187 188 189 190
191 192a 192b 193a 193b 194 195 196 197**

Use the numbers below for Products advertised in this issue:

**IFC 3R 4,5A 6A 8L 9A 10L 11A 12,13A 14A 15A 16A 17A
18L 19A 20A 21A 22,23A 24L 25A 26A 27A 28L 29A 30A 31A
32A 33A 34L 35A 36A 37A 38A 39R 40L 41A 42A 43A 44L
45A 46A 48A 486A 55A 56A 57A 59A 60L 65R 67A 68A
73A 75A 77A 78L 79A 80L 81A 82L 83A 84L 85A 86L 87A
89A 90L 91A 92L 93A 94L 95A 96L 97A 98L 99A 100TL 100BL
100TR 100BR 101R 102L 102BR 103R 104L 105R 106TL 106BL
107R 108TL 108BL 108BR 109R 111R 113TL 113R 114L 115TR
115BR 116TL 116BL 117R 118L 119TR 119BR 120TL 120BL 121R
122L 123TR 123BR 129TL 129BL 129R 130L 131R IBC OBC**

Chemical Engineering Progress Data Service

Name ....

Position ....

Company ....

Address ....

City ....**Zone**......**State** ....

☐ **I want a subscription to C.E.P. Bill me $6.00 for a year.**

November, 1955

Please do not use this card after February, 1956

Use the following numbers for data-literature from the Chemical Exposition:

**1 2 3a 3b 4 5 6 7 8 9 10 11 12a 12b
14 15 16 17 18 19 20 21 22 23 24 25 26 27
28 29 30 31 32 33 34 35 36 37 38 39 40 41a
41b 42 43 44 45 46 47 48 49 50 51 52 53 54a
54b 55 56 57 58 59 60 61 62 63 64 65 66 67
68 69 70 71 72 73 74 75 76 77 78 79 80 81
82 83 84 85 86 87 88 89 90 91 92 93 94 95
96a 96b 97 98 99 100 101 102 103 104 105 106 107 108
109 110 111 112 114 115 116 117 118 119 120 121 122 123
124 125 126 127 128 129 130 131 132 133 134 135 136 137
138 139 140 141 142 143 144 145 146 147 148 149 150 151
152 153 154 155 156 157 158 159 160 161 162 163 164 165
166 167 168 169 170 171 172 173 174 175 176 177 178 179
180a 180b 180c 181 182 183 184 185 186 187 188 189 190
191 192a 192b 193a 193b 194 195 196 197**

Use the numbers below for Products advertised in this issue:

**IFC 3R 4,5A 6A 8L 9A 10L 11A 12,13A 14A 15A 16A 17A
18L 19A 20A 21A 22,23A 24L 25A 26A 27A 28L 29A 30A 31A
32A 33A 34L 35A 36A 37A 38A 39R 40L 41A 42A 43A 44L
45A 46A 48A 486A 55A 56A 57A 59A 60L 65R 67A 68A
73A 75A 77A 78L 79A 80L 81A 82L 83A 84L 85A 86L 87A
89A 90L 91A 92L 93A 94L 95A 96L 97A 98L 99A 100TL 100BL
100TR 100BR 101R 102L 102BR 103R 104L 105R 106TL 106BL
107R 108TL 108BL 108BR 109R 111R 113TL 113R 114L 115TR
115BR 116TL 116BL 117R 118L 119TR 119BR 120TL 120BL 121R
122L 123TR 123BR 129TL 129BL 129R 130L 131R IBC OBC**

Chemical Engineering Progress Data Service

Name ....

Position ....

Company ....

Address ....

City ....**Zone**......**State** ....

☐ **I want a subscription to C.E.P. Bill me $6.00 for a year.**

November, 1955

products-(Cont.)

93A Stainless Steel Plate. Available for quick delivery, to your specifications, stainless steel plate sheared, sawed, or cut to measure. G. O. Carlson, Inc.

94L All-Chem Pumps. Features are capacities 1 to 10 gal./min. at 1,750 rev./min. to 150 lb./sq.in., good flow characteristics, positive displacement, etc. Eco Engineering Co.

95A Insulation. You will get efficient insulation by consultation with a Johns-Manville contactor. Be sure to call on him.

96L Air Classifier. Without interrupting operations you can change from 40 to 400 mesh & maintain the size continuously. The Gyrotor combined with the Hardinge Co., Inc. grinding mill results in an integrated system.

97A Stainless Steel & Alloys. Requirements of the petroleum & chemical industries demand resistance to corrosion & abrasion, & other conditions. Solid stainless does the job. Stainless cladding may answer. Sun Shipbuilding & Dry Dock Co.

98L Power Transmission Equipment. Couplings, pulleys, transmissions, joints, a complete line of modern equipment on display in the Chem Show exhibit of Lovejoy Flexible Coupling Co.

99A Crystal Dehydrator. Low possible moisture content, high capacity & purity & continuous operation are features of Super-D-Hydrator. Two sizes 20 & 27 in. Sharples Corp.

100TL Filter Sheets. Ten uniform grades of asbestos filter sheets in sizes to 25 in. sq. Trial sheets without obligation. Ertel Engineering Corp.

100BL Spray Nozzles. Thousands of industrial spray nozzle types & sizes to choose from. A new 48-page catalog available. Spraying Systems Co.

100TR Pipe & Tube. Either ferrous or non-ferrous pipe or tube ½ to 8 in. iron pipe size. Also bends & welded assemblies. Rempe Co.

100BR Buna N Units. Pumps, valves, & fittings of Buna N resist acids, alkalies, salts & fumes at temperatures to 225° F. Bulletin HR-2 tells the full story. Vanton Pump & Equipment Corp.

101R Press Closer. A new hydraulic Hydro-Lock filter press closer converts a manually operated press in less than an hour. Biach Industries, Inc.

102L Tetrines. In their purest forms available commercially from a new plant specially designed to make these products. Glyco Products Co., Inc.

102BR Jobs in New England. Professional diversity & growth of opportunity are offered in a variety of listed fields. Apply to Arthur D. Little, Inc.

103R Pumps. Hydrex pumps for pumping corrosive chemicals are simple, heavy duty units. Can be direct-connected to 1,800 rev./min. Sier-Bath Gear & Pump Co., Inc.

104L Liquid Level Control. Called Magnetrol the unit is so simple that specials are likely to be standard. Solves many tough level control problems. Magnetrol, Inc.

105R Resins. Panarez hydrocarbon resins for use whether you compound or use rubber for soles, wire covering, or other purposes. Pan American Chemicals Corp.

106TL PVC Piping. Injection molded fittings in PVC piping has long life & ends shutdowns. Pressures to 100 lb./sq.in. Tube Turn Plastics, Inc.

106BL Sprocket Rim. Every valve becomes easily accessible using this adjustable sprocket rim with chain guide. Fits any size valve wheel. Babbitt Steam Specialty Co.

107R Filters. Three types of filters now available for continuous filtration—string, horizontal & scraper types. Details & analyses available. Filtration Engineers, Inc.

108TL Laminates. Glass reinforced polyester, epoxy & phenolic laminates for corrosion resistance & electrical insulation. Molded & fabricated by Carl N. Beetle Plastics Corp.

108BL Vacuum Equipment. Steam jet ejectors, condensers, other vacuum equipment fabricated from variety of materials. Jet-Vac Corp.

108BR Dust Sampler. The Konisampler for continuous & accurate dust sampling, employs principle of thermal precipitation. Joseph B. Ficklen III.

109R Centrifuges. Visit the display of Centrico Inc. at the Chem Show & see these modern units for continuous chemical processing.

111R Heat Exchanger. With Paracoil the self-cleaning heat exchanger down time is eliminated in the event of tube fouling. Davis Engineering Corp.

113TL Research. If you have a research problem to solve whether it be little or large, consult Foster D. Snell, Inc.

113R Process Equipment. Whatever your process or your need be it a filter, mixer, or storage & mixing tank you can get the right unit with the proper application from Alsop Engineering Corp.

114L Couplings. Pushomatic quick couplings for vacuum filtration & other air, hydraulic, or fluid handling application. Ace Glass Inc.

115TR Process Equipment. DehydrO-Mat variable inclination, also heavy-duty rotary dryers, & rotary coolers available from Edw. Renneburg & Sons Co.

115BR Laboratory Equipment. Laboratories are synchronized using Metalab Equip. Co. units. Interchangeable & flexible Catalog.

116TL Kerodex. Spreads like a cream & acts like a glove to protect against damaging substances. Ayerst Laboratories.

116BL Catalyst Supports. Over two dozen types offered including variety of combinations. Carborundum Co.

117R Mixers, Pumps, Valves. Various types manufactured by Rheinhuette in operation. See display of Neumann & Weaver, Inc. at the Chem Show.

118L Storage Tanks. Pla-Tank resin-bonded glass fiber laminate units offer many advantages including light weight, resistance to acids, fumes & temperatures. Chemical Corp.

119TR Process Equipment. Stainless steel tanks & other items in the line displayed at Booth 301 the Chem Show. Arthur Colton, Inc.

119BR Filter Press Closer. The Handraulic closing device easy to install & operate. Catalog of presses & accessories. D. R. Sperry Co.

120TL Process Problems. Chemical engineering design, mechanical engineering development, facilities for manufacture enable Artisan Metal Products Inc., to solve your problems.

120BL Valves. Designed for remote control this superpressure valve controls pressures to 60,000 lb./sq.in. American Instrument Co.

121R Defoamers. Silicone defoamers are efficient & versatile in countless applications. Dow Corning Corp.

122L Photochemical Equipment. For use in laboratory, pilot plant or full plant operations. Hanovia Chemical & Mfg. Co.

123TR Jet Mixer. The Hermas jet gives 3 kettles in place of 2 without vortex or foam. Does a better mixing job. Hermas Machine Co.

123BR Diffusion & Heat Exchange. These actions in chemical kinetics are the subject of a volume from Princeton University Press.

129TL Arched Wafers. A new shape arriving at solidification between —60° C. & +200° C. Flakice Corp.

129BL Pyrometer. Instrument designed to meet all plant & laboratory surface temperature measurements. Five standard ranges available. Pyrometer Instrument Co.

129R De-Ionizer. A package unit completely assembled & factory tested in two- & mixed-bed models. Capacities 150 to 1,000 gal./hr. Illinois Water Treatment Co.

130L Laboratory Equipment. Every type of lab equipment fabricated from Vitreosil. Answers the most exacting needs. Thermal American Fused Quartz Co., Inc.

131R Vacuum Units. Multi-stage steam jet Evactor units maintain industrial vacuum to 99.99% of perfect. Croll-Reynolds Co., Inc.

486A Valves. Precision made Powell valves meet every specification every time. Consult your distributor. Wm. Powell Co.

IBC Controlled Volume Pump. Be sure to see this new pump with automatic stroke length adjustment by instrument air signal when you visit the Chem Show. Milton Roy Co.

OBC Mixers. For mixing fluids in a big way the Lightnin. Guaranteed unconditionally to do the recommended job. Mixing Equipment Co., Inc.

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Carbon Div., Great Lakes Carbon Corp. Booth 306-308
See Great Lakes Carbon Corp.

Carborundum Co., The, Niagara Falls, N. Y. Booth 347
Ceramic products; refractories, fibers, porous media.

Carlisle Mach. Works, Millville, N. J. Booth C-141
D.S. 41a—Laboratory & shop gas burning apparatus.
Personnel: *J. Bolnick, pres.; J. C. Kania; G. Sharp; Alyce Kingston.*

Carpenter Steel Co., Union, N. J. Booth 832
(See The Alloy Tube Div.)

Carrier Conveyor Corp., Louisville, Ky. Booth 117

Carver Inc., Summit, N. J. Booth 8
Hydraulic presses; filter presses.

Catalytic Comb. Corp., Detroit, Mich. Booth C-133

Centrico Inc., Englewood, N. J. Booth 731
D.S. 41b—New, automatic centrifugal de-sludger. Available in non-corr. matls. capacity to 1700 gal./hr., bowl speed 6500 rev./min.; sludge holding space 1.5 gals. Also new, totally-enclosed lab. centrifugal separator. Suited to volatile materials.
Bulletins: (1) Covers all types of automatic de-sludgers. (2) Gen. bulletin on centrifugation problems & solutions. Also specific bulletins on individual members of line.
Personnel: *O. Mueller-Habig, pres.; P. Stahl, chf. engr.; J. Spiekermann, secy.; C. H. Maass, sales mgr.; W. Wendenburg; A. Peitzmann.*

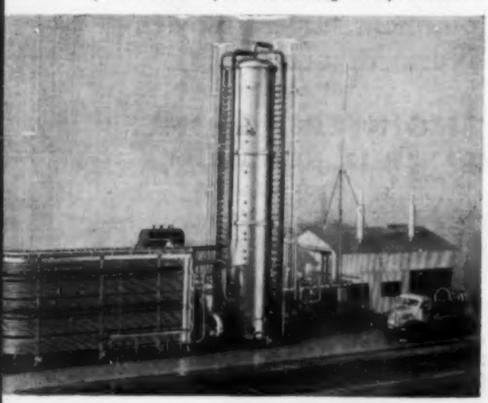
Cesco, Santa Rosa, Calif. Booth S-68

Chain Belt Co., Milwaukee, Wis. Booth 432
D.S. 42—Conveyor & power drive chains, buckets, etc.
Personnel: *R. V. Poisson, sales mgr.; G. H. Woodland, gen. sales mgr. indus. divs.; J. N. Tuft, sales mgr.; J. W. Snavely; G. J. Schuelke; G. H. Pfeifer, adver. mgr.*

Chemical Corp., The, Springfield, Mass. Booth C-120
Reinforced plastic vessel equipment.

Chemical Div., New York, N. Y. Booth 706
(See Nat'l. Lead Co.)

Chemical & Indus. Corp., The, Cincinnati, Ohio. Booth S-27
D.S. 43—Model of ammonia oxidation plant & ammon. nitrate plant using CSC Stengel process. See below.
Bulletins: Brochures showing photos & giving descrip. of each process. Brochures on complex fertilizer produced using PEC processes.



Cleveland Worm & Gear Variator. See below.

Personnel: *D. M. Carr, v. p. engrg.; F. J. Tytus, chf. engr.; H. W. Van Ness, chge. proj.; H. A. Dennis, asst. to pres.; A. M. Taylor, Jr., dir. sales.*

Chem. Plants Div., Pittsburgh, Pa. Booth 103
(See Blaw-Knox Co.)

Chemicolloid Labs., Inc., Garden City Pk., N. Y. Booth 22
D.S. 44—Charlotte pilot plant colloid mill—new. Has 2 h.p. motor. Adaptable to systems under high press. Also a heavy duty chem. proc. unit; plus a stand. unit.
Bulletins: "The Charlotte Colloid Mill"—8-p., shows models, appins., specs.
Personnel: *D. F. O'Keefe, pres.; L. E. Putnam, v.p.; R. L. Anderson, asst. fld. dir.; W. R. O'Keefe, prod. mgr.; W. A. Behrens, chf. engr.*

Chemineer, Inc., Dayton, Ohio. Booth C-155
D.S. 45—Exper. lab. agitator; working model of TurboTube agitator; gear driven side enter. agitator.
Bulletins: Data sheets.
Personnel: *R. A. Schaeffer, pres.; R. L. Bates, tech. dir.; W. W. Korsgren, chf. des. engr.; P. A. Chapman; R. A. Mueller; W. Calihan.*

Chempump Corp., Phila., Pa. Booth 314-316
D.S. 46—Seal-less centrif. pumps. New series S "canned" pumps—low-cost units. Also new double-ended series DE two-staged "canned" pumps. For temps. to 700° F.; pressures 2,500 lb./sq.in. Other units in line.
Bulletins: Bull. 1010 on standard Chempump series E, C, CF, CFH, & CS. New No. 1020 & 1030 on series S & DE.
Personnel: *D. P. Litzenberg, v. p. sales; H. T. White, v. p. sales; A. D. Fell; H. L. Laitner; H. A. Thornton; R. H. MacFetrich.*

Chiksan Co., Brea, Calif. Booth 607
Swivel joints.

Cleveland Mixer Co., The, Bedford Hts., Ohio. Booth 825
Broad line of liquid, liquid-solid, & solids mixing equipment.

Cleveland Worm & Gear Co., The, Cleveland Ohio. Booth 72
D.S. 47—Vertical-type worm gear speed for reducer driving mixing propeller. A new ball-bearing variable speed drive, range 9:1 from const. speed power source.
Bulletins: 8-p. worm gear vert. speed reduc.; 8-p. speed Variator—both selection guides, with specs.
Personnel: *L. O. Witzenburg, gen. sales mgr.; R. E. Dittoe, sales mgr.; W. M. Stilwell; J. T. Gordon; R. C. Jones; H. H. Platek, asst. adver. mgr.*

Cochrane Corp., Philadelphia, Pa. Booth S-111

Colonial Plastics Mfg. Co., The, Cleveland, Ohio. Booth S-24

Colton Co., Arthur, Detroit, Mich. Booth 301
D.S. 48—High speed mixing, filling, drying, granulating tabletting, and coating equipment.
Bulletins: 24-p. on mixing, drying & tabletting equip.; 8-p. on filling equip.
Personnel: *K. B. Hollidge, exec. v. p.; W. A. Doepel, sales mgr.; N. C. Carman, dir. cust. serv.; L. P. Gajda, dir. engrg.; C. C. Edgar; W. I. Smith.*

Combustion Engr., Inc., Chicago, Ill. Booth 68
(See Raymond Div.)

Commercial Filters Corp., Melrose, Mass. Booth 310
D.S. 49—Fulflo filters of corros.-resis. materials for flow rates to 1,000 gal./min. Employ filter tubes of synthetic & glass fibers.
Personnel: *R. L. Fielding, pres.; J. R. Chisholm, asst. sales mgr.; J. V. Calhoun; R. Schadler.*

Conkey Filter Unit, New York, N. Y. Booth 42-44
(See Genl. Amer. Trans. Co.)

Conoflow Corp., Philadelphia, Pa. Booth 639
D.S. 50—Pneumatic-electric transducer for remote regulation of electric current; pneumatically-positioned power operators for throttling control service; pneumatic regulators for press., differential, ratio, & reversal; also Saunders diaphram type auto. control valves.
Bulletins: 8-p. series H pneu. regulators; 4-p. on current controller; 12-p. on Conomotor power operators.
Personnel: *J. C. Koch, v. p. & genl. mgr.; W. Brand, v. p. & chf. engr.; J. B. Madison; C. P. Boyd; H. Hartz; W. Hagan.*

Continental Can Co., Inc., N. Y., N. Y. Booth 29
(See Fibre Drum Div.)

Continental-Diamond Fibre Co., Newark, Del. Booth 534

Controls Div., Norwood, Mass. Booth 602
(See Control Engr. Corp.)

Cooper Alloy Corp., Hillside, N. J. Booth 602
Stainless steel valves, fittings. Also castings.

Corning Glass Wks., Corning, N. Y. Booth 25-27
D.S. 51—Two new modular glass heat exchangers shell & tube type—13½ & 50 sq. ft. sizes. Easily assembled to provide systems of flexible operation. Made of glass, Teflon & ceramic, for max. corr-resis. See below.

Bulletins: Design manual for Pyrex brand shell & tube exchangers. Tells how to select, lay out & engr. systems.
Personnel: F. F. Fleischman, sales mgr.; R. Collard; E. Lofberg; H. Travers; C. Esposito.

Cowles Dissolver Co., Cayuga, N. Y. Booth C-22
High speed (up to 7500 ft./min. impeller speed) dispersion-type mixers.

Crane Co., Chicago, Ill. Booth 108
D.S. 52—Corros.-resis. alloy valves. In 18-8 SMO & Craneloy 20. Teflon packing.
Bulletins: 12-p. complete line of corros.-resis. valves. Sizes, dimens., applns.
Personnel: J. A. Dwyer; G. G. Lindholm, mgr. indus. sales; E. G. Habenicht, asst. mgr. indus. sales; J. W. Greene; J. E. Bradbury, mgr. chem. sales; F. J. Wagner.

Croll-Reynolds Engrg. Co., Inc., New York, N. Y. Booth 234
D.S. 53—ClaRrite pressure filters type liq. clarification filters. FlexoDisc heavy duty expansion joints.
Bulletins: 4-p. ClaRrite filters—cutaway views, size & filter element data. 8-p. expansion joints estimating guide.
Personnel: R. S. Croll, pres.; J. J. Quinlan, v. p.; L. O'Hanlon; R. F. Young; P. P. Ventura.

Calvert Div., Cleveland, Ohio. Booth 535-539
(See Republic Steel Corp.)

Cuno Engrg. Co., The, Meriden, Conn. Booth 239
D.S. 54a.—Pressure filters employing unique metal disc, porous s.s., or other filter elements.
Personnel: C. H. Winslow, v. p. sales; D. H. Van Vleck, mgr. ind. sales; E. D. Kane, dir. dev.; J. E. Duff, east. sales mgr.; G. S. Miller.

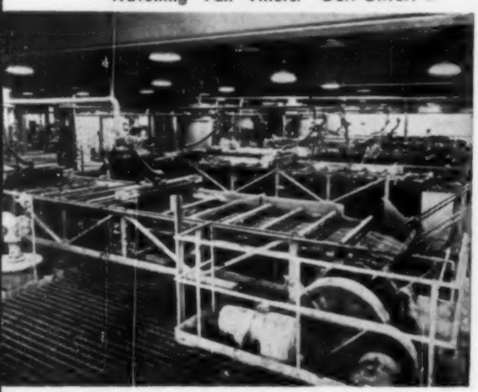
Darco Dept., N. Y., N. Y. Booth 302-304-401
(See Atlas Powder Co.)

Davenport Mach. & Fdry. Co., Davenport, Ia. Booth C-39
Rotary dewatering presses, rotary dryers.

Davis Instr. Div., Newark, N. J. Booth 939
(See Davis Emergency Equip. Co., Inc.)

Day Co., The Minneapolis, Minn. Booth 5
D.S. 54b.—Demonstration of new principle automatic contin., small capac., dust filter. Vert. cyl. filter uses piston reversing air through filter media 1 tube at a time. Gives high air-cloth ratios. Also demonstr. of self-adjusting blow rings for Day reverse jet filters—rings follow distortions.

Travelling Pan Filters. *Dorr-Oliver.* ►



Bulletins: 24-p. "Dust Filter Facts" broch. illus. latest devels. of "AC" filter & access. with cap. charts, dimens., etc.
Personnel: R. E. Gorgen, exec. v. p.; A. E. Swanson, mgr. filter dept.; E. W. Anderson, mgr. Buffalo plant; T. A. Collier; J. F. Kern; R. Jensen.

Day Co., Inc., The J. H., Cincinnati, Ohio. Booth 921-925
D.S. 55—Kneading & blending equipment; three-roll dispersion mill with new adjustment feature; gyratory sifter; pony (double-motion agitator) mixer.
Bulletins: 8-p. compl. data on ribbon blenders, with sizes, dimens., & photos. 8-p. Imperial mixers compl. data on sigma blade units includ. sizes, spec. & photos.
Personnel: J. L. Diltz; I. Wershay; R. N. Harris; C. A. McBride; R. Mader; R. Schmitt.

Dean Products Inc., Brooklyn, N. Y. Booth 744

DeLaval Separator Co., The, Poughkeepsie, N. Y. Booth C-16
Centrifuges.

Delaware Barrel & Drum Co., Inc., Wilmington, Del. Booth C-25
D.S. 56—Molded polyethylene tanks with capacity range 5 to 160 gal. Also molded drums, tanks, faucets, & polyethylene coated drums & valves.
Bulletins: Broch. 7-p. shows molded drums & tanks, titled "Properties & Uses of Delaware's Molded Polyethylene Containers.
Personnel: J. S. Heisler v. p. sales; L. Gaev; B. J. Lobermann; J. Barber; A. Starr; D. Carswell.

Derrick Mfg. Co., Buffalo, N. Y. Booth C-28
D.S. 57—High frequency vibrating screens, conveyors, feeders, shakers, packers.
Bulletins: 4-p. folder on eccentric-motor screens; cutaway views, dimens. data.
Personnel: H. W. Derrick, Jr., pres.; R. G. Derrick; R. E. Vail.

DeZurik Shower Co., Sartell, Minn. Booth 423

Dicalite Div., Los Angeles, Calif. Booth 306-308
(See Great Lakes Carbon Corp.)

Dore Co., J. L., Houston, Texas. Booth C-139
Teflon gaskets, tubing.

Dorr-Oliver Inc., Stamford, Conn. Booth 5-13-517
D.S. 58—New equipment comprises traveling pan filter, commercial size DorrClones of porcelain, 30 & 50 mm. rubber block, and 6, 12 & 24 in. diam. rubber lined units. Also Oliver type L centrif. pump in smaller sizes for corros. resis. service. Other displays will include Oliver continuous filters, pumps, thickeners, and the FluoSolids system.
Bulletins: 12-p. on continuous processing, with brief descriptions entire D-O equip. line. 6-p. on type M molded rubber block DorrClone, incl. operating data. 8-p. type rubber lined FR DorrClone with operating data. 6-p. on type-L centri. pump with deliv. vs. head chart. 4-p. Fluo Solids; 8-p. Oliver filters; 6-p. Dorr engrg. services.
Personnel: T. B. Ford, v. p. sales; W. E. Smith, asst. genl. sales magr.; G. O. Wilson, N. A. indus. genl. sales mgr.; G. G. Reed, N. A. fil. sales mgr.; W. B. Gery; R. B. Thompson, Fluo-Solids sales mgr.

Downingtown Iron Wks., Inc., Downingtown, Pa. Booth 714
D.S. 59—Fabricated vessel equip., incl. heat exchangers.

Eastern Stainless Steel Booth, see *below*.

Bulletins: 16-p. on heat exchangers incl. tube sheet layout tables showing tube count. Sample calc. mech. dsign of typical heat exch.
Personnel: E. C. Ashton, sales mgr.; J. L. Dixon; F. Rubin; W. Pratt; W. C. Short; C. E. Raysor.

Draco Corp., Cleveland, Ohio. Booth 808
Dust collectors & systems.

Dudco Division, Detroit, Mich. Booth 333-335
(See N. Y. Air Brake Co.)

DuPont de Nemours & Co., E. I., Wilmington, Del. Booth 813

Duralab Equip. Corp., Bklyn, N. Y. Booth C-57

Durion Co., Inc., Dayton, Ohio. Booth 34
Centrifugal pumps, valves, pipe, heat exchangers and other proc. equip. of cast corros.-resis. alloys. Also Enzinger vertical leaf press. filters.

Durametallic Corp., Kalamazoo, Mich. Booth 223
D.S. 60—A rotary mech. seal designed for high temp. (to 800° F. for oil or water) service. Two types—unbalanced & balanced assemblies. s.s. construc. Also packing & flex. handle packing tools.
Bulletins: Dura Seal bull. on new Hot Seal. Dura Seal cat. on var. types mech. seals according to applications.
Personnel: J. L. McQuillen; R. R. Smith, sales mgr.

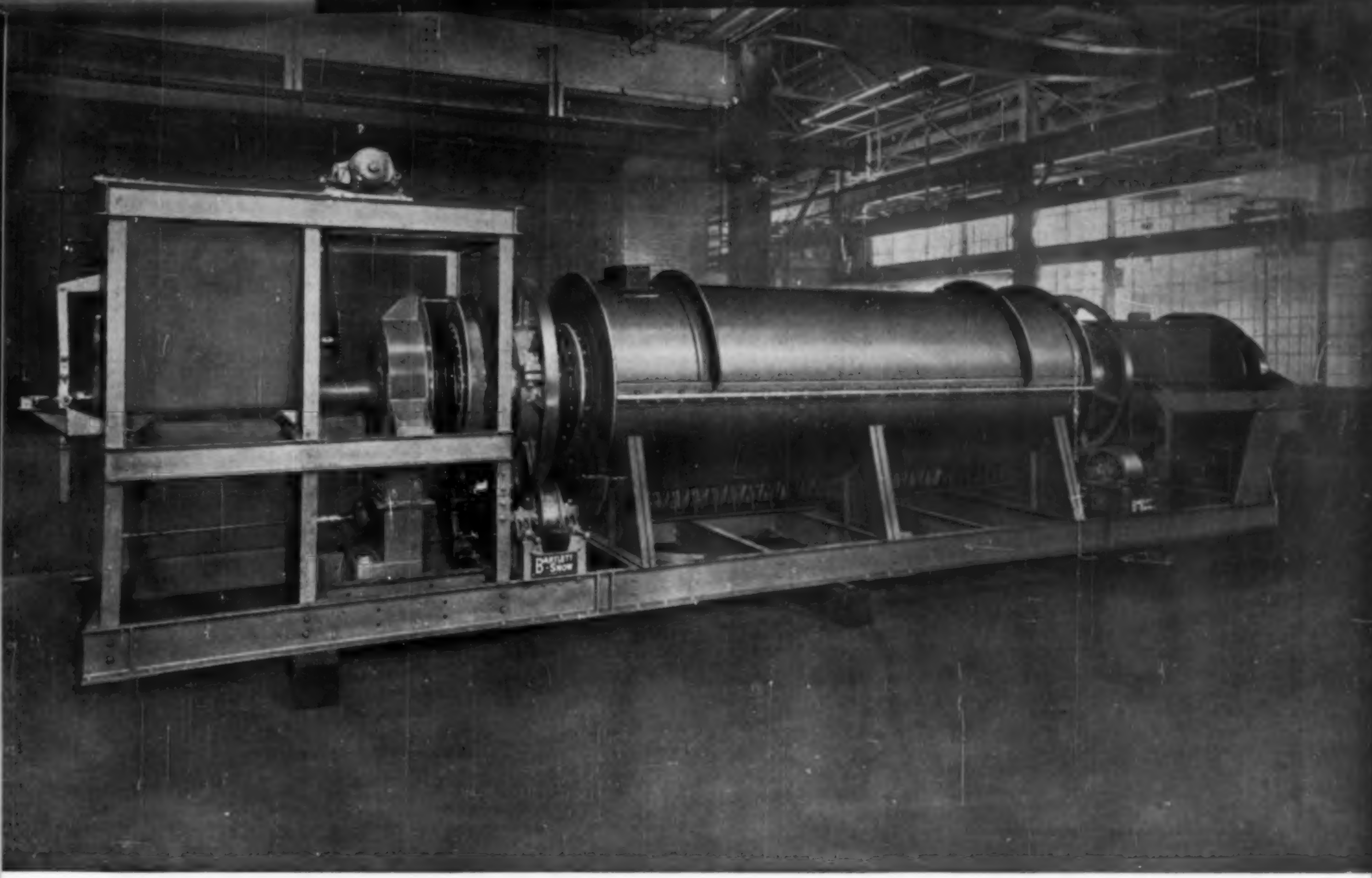
Durock Corp., West Pawlet, Vt. Booth C-153

Dust Suppression & Engrg. Co., Lake Orion, Mich. Booth C-163
D.S. 61—Air Tumbler—horizontal wet type centrifugal dust collector.
Bulletins: 12-p. cat. Air Tumbler gives tech. data, cutaway views, appln's, etc. 4-p photos of installations.
Personnel: G. C. Zilıotto, owner & mgr., A. G. Mutimer; R. C. Flood; R. E. Innes; J. F. Kern, Jr.; R. H. Jensen.

Dustex Corp., Buffalo, N. Y. Booth 413
D.S. 62—Mechanical dust collectors.
Bulletins: File folder includes descrip. & engrg. data on var. types of Microclone & Dustex collectors.
Personnel: H. O. Hazel, pres.; W. A. Foote, sales mgr.; H. E. Friederich; J. F. Phillippi; E. C. Metrick; C. L. Maisch.

Eastern Stainless Steel Corp., Baltimore, Md. Booth 126
D.S. 63—S.S. sheets & plates. All s.s. finishes will be shown.
Bulletins: 1955 ed. "S.S. Handbook for the

(*Continued on page 78*)



25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Fabricator." Also, Shop Manual, and bklt. on Sheets & Plates.
Personnel: E. A. Haggenmuller, dir. sales; J. W. Stottlemyer, asst. dir. sales; N. L. Ellis; W. E. Walton; R. J. Engelhardt; J. L. Taft.

Eaton-Dikeman Co., Mt. Holly Springs, Pa. Booth 425
D.S. 64—Filter papers for indus. use in filter presses; also lab papers.
Bulletins: New brochure on "How To Select Filter Paper for Industrial Filtration."
Personnel: E. H. Olmstead, v. p.; Mrs. F. T. Yeingst, asst. sales mgr.; E. W. Dowd, supt.; C. U. Stevens, tech. dir.; W. F. Skilton.

Eclipse Fuel Engineering Co., Rockford, Ill. Booth 747
Package steam generators.

Eco Engineering Co., Newark, N. J. Booth 647
D.S. 65—Positive displacement pumps in 316 s.s., No. 20 Alloy & Hastelloy C with Teflon or carbon impellers & Teflon ceramic seals for corrosives. Also, centrifugal pump of Carpenter 20 s.s.
Bulletins: 4-p. guide to entire line. Single page on close-coupled low-cost pump. 4-p. folder on pilot plant pumps.
Personnel: J. Eisenberg, sales engr.; E. Anderson.

Eiche & Associates, Inc., Newark, N. J. Booth C-123—C-127

Eimco Corp., Salt Lake City, Utah. Booth C-9
D.S. 66—Information & photos on several new filters and new features of regular filter line.
Personnel: P. O. Richter, sales mgr. filters; M. M. Kaiser; T. S. Ullmann, export mgr.; W. L. Dowdey; C. R. Picek; J. Apotheker.

Electric Hotpack Co., Inc., Phila., Pa. Booth 67
D.S. 67—25 cu. ft. vertically convected drying oven with uniform temps. throughout chamber. Used for baking finishes, aging, equipment drying for pilot plants. For temps. to 180° F. Also other ovens, baths, furnaces.
Bulletins: 4-p. on appln's. requiring const. temps. A 4-p. complete line of lab. equip. 4-p. lab. hazards from explosive vapors.
Personnel: A. S. Mann, sales mgr.; P. Layne; H. Kreinberg; W. T. White; I. McFarland; H. Limperis.

Electrode Div., New York, N. Y. Booth 306-308
(See Great Lakes Carbon, Corp.)

Emery Industries, Inc., Cincinnati, O. Booth 718
D.S. 68—New items are: Lubricant esters—bases for syn. lubr. fluids & greases. Low-temp. plasticizer for syn. rubbers. Polymerized fatty acid, C_{36} dibasic. Polymerized fatty acid, C_{54} tribasic; Others.
Bulletins: 20-p. Emersol oleic acids. 3-p. Plastolein. 16-p. Emolein esters for syn. lubr. fluids & greases.
Personnel: K. K. Boyd, v. p. sales & pur.; R. F. Brown, chem. sales mgr.; R. T. Hull; N. A. Ruston dir. dev. & serv.; W. T. Meinert; A. Moore.

Emsco Mfg. Co., Los Angeles, Calif. Booth C-123—C-127

Engelhard Industries, Newark, N. J. Booth C-17, C-19, C-21

Entoleter Div., New Haven, Conn. Booth 703
(See Safety Car Htg. & Ltg. Co.)

Enzinger Div., Duriron Co., Angola, N. Y. Booth 34
See Duriron Co.

(Continued on page 80)

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Eriez Mfg. Co., Erie, Pa. Booth S-157
D.S. 69—Complete line of perm. magnetic equip. for removal of iron from chem. proc. lines. New drawer type & double-bank grate magnets for dry, free flowing matls. Also new perm. mag. Ferrotraps for liquid flow lines.
Bulletins: Magnetic Ideas from new book B-213. 150 ideas on how magnets solve problems. 4-p. Ferrotrap; 4-p. grate magnets include dimensional data.
Personnel: R. A. Roosevelt, sales mgr.; N. Hirt; J. Sigafoos.

Ertel Engrg. Corp., Kingston, N. Y. Booth 614
D.S. 70—New items are a tube type precoat pressure filter & a plastic filter. S.S. filter presses, asbestos disk & plastic filters, s.s. pumps, & many other items.
Bulletins: Model EPF plastic filter; comp. line of lab. filters; semi-auto. vacuum bottle filling machines.
Personnel: F. Ertel, pres.; G. Vogel, genl. sales mgr.; J. Schomer, dir. res.

Exact Wt. Scale Co., The, Columbus, Ohio. Booth S-12
D.S. 71—An auto. net weighing mach. for packing, sacking, batching, etc. Two models—capac. 4 grams to 3 lb. & 3 to 10 lb. Both with 3 cu.ft. storage hopper. Full line of manual scales.
Bulletins: 4-p. weighing mches (semi-automatic); data sheets on Shadowgraph & other production models.
Personnel: W. A. Scheurer, v. p. & sales mgr.; R. Rapp; W. J. Schieser; J. E. Konkle; R. White; W. W. Jones.

Exolon Co., Tonawanda, N. Y. Booth 609

Falls Industries, Inc., Solon, Ohio. Booth 37

Farval Corp., Cleveland, Ohio. Booth 72
D.S. 72—Centralized lubrication systems. Introducing new means of spraying lubricant directly on large gears. Automatically controlled.
Bulletins: No. 26-R on centralized systems shows functions of elements, gives dimensions, survey data. No. 16, same on Multival manual lubricating system.
Personnel: L. O. Witzenburg, genl. sales mgr.; H. H. Platek; W. M. Stilwell; J. T. Gordon; R. C. Jones; G. T. Collatz.

Federal Refractories Corp. Mineral City, Ohio. Booth 10-12-14

Fenwal, Inc., Ashland, Mass. Booth 909
D.S. 73—New series 560 thermostat-actuated controller. Designed for precise control including on-off, adjustable bandwidth, & proportioning.
Bulletins: Complete 16 p. cat. 500 of indus. elec. temp. control & detection devices with complete design information. A 4-p. brochure on the snap-action thermostat line.
Personnel: S. Edgerly, indus. sales mgr.; R. H. Anderson, asst. indus. sales mgr.; R. C. Johnson, sales prom.; J. P. Sullivan; J. M. Lancaster.

Ferranti Electric, Inc., N. Y., N. Y. Booth S-67

Filtration Engineers, Inc., Newark, N. J. Booth 3

Filtros, Inc., Rochester, N. Y. Booth 419
D.S. 74—On display—filter media of porous quartz, with organic-bond type; porous carbon, & refractory clay types. Filtros 35—electrolytic porcelain diaphragm matl.; porous ceramic catalyst supports; water filters; & porous thermoplastic electrolytic diaphragms.
Bulletins: Cat. No. 10 covers filter media, its

(Continued on page 82)

selection & application. Folder Filtros 35 on porc. electro. diaphragms. No. 11 on por. carbon filter media. Folder on Flo-Clear filters. *Personnel: R. G. McDonald, pres.; T. Evans, plant mgr.; G. Hyland, asst. plant mgr.*

Fischbein Co., Dave, Minneapolis, Minn. Booth 640
D.S. 75—Portable bag closers (sewing) for any type of paper or textile bags.
Bulletins: Folder illustrates unit, describes use.
Personnel: G. Fischbein, genl. mgr.; S. Shark.

Fischer & Porter Co., Hatboro, Pa. Booth 200-202

Fitzpatrick Co., The W. J., Chi., Ill. Booth 140

Fletcher Wks., Inc., Philadelphia, Pa. Booth 102
D.S. 76—Display consists of 32 in. suspended centrifugal with fully automatic operation with new style fume hood & pneumatic unloader which may be manual or automatic. Also 12 in. lab. centri. with var. speed drive.
Bulletins: Pamphlet describing 32" centri.
Personnel: W. H. Rometsch, secy.-treas.; W. Egee, chf. engr.; L. P. Egee; H. N. Rahn; H. B. Allison.

Flexitallic Gasket Co., Camden, N. J. Booth 732

Food Engineering, New York, N. Y. Booth 501

Food Machinery & Chem. Corp., Lansing, Michigan. Booth 326 (John Bean Div.)

Food Machinery & Chem. Corp., Los Angeles, Calif. Booth 805

Foster Engineering Co., Union, N. J. Booth 208

Foxboro Co., The, Foxboro, Mass. Booth 139
D.S. 77—New—type C Vernier Valvactor, compact, motion balance valve positioner. Applies full pressure needed for high speed corrective action. Also 14A Pneu. Continuous Integrator for 3-15 lb./sq.in.; Magnetic Flowmeter; a type 13A d/p cell transmitter for flow, level, diff. pressure—advanced des. for flow, level, diff. press. measurements. Also an EMF/Pneu. Transmitter which converts millivolts to 3-15 lb./sq.in. signal for use with standard receivers.
Bulletins: Data on above products.
Personnel: H. O. Ehrisman, genl. sales mgr.; V. A. Pardo; J. C. Hawkins; J. B. Deaderick; E. R. Huckman; J. D. Mason.

Fuller Co., Catasauqua, Pa. Booth 213

Fulton Bag & Cotton Mills, New Orleans, La. Booth 820

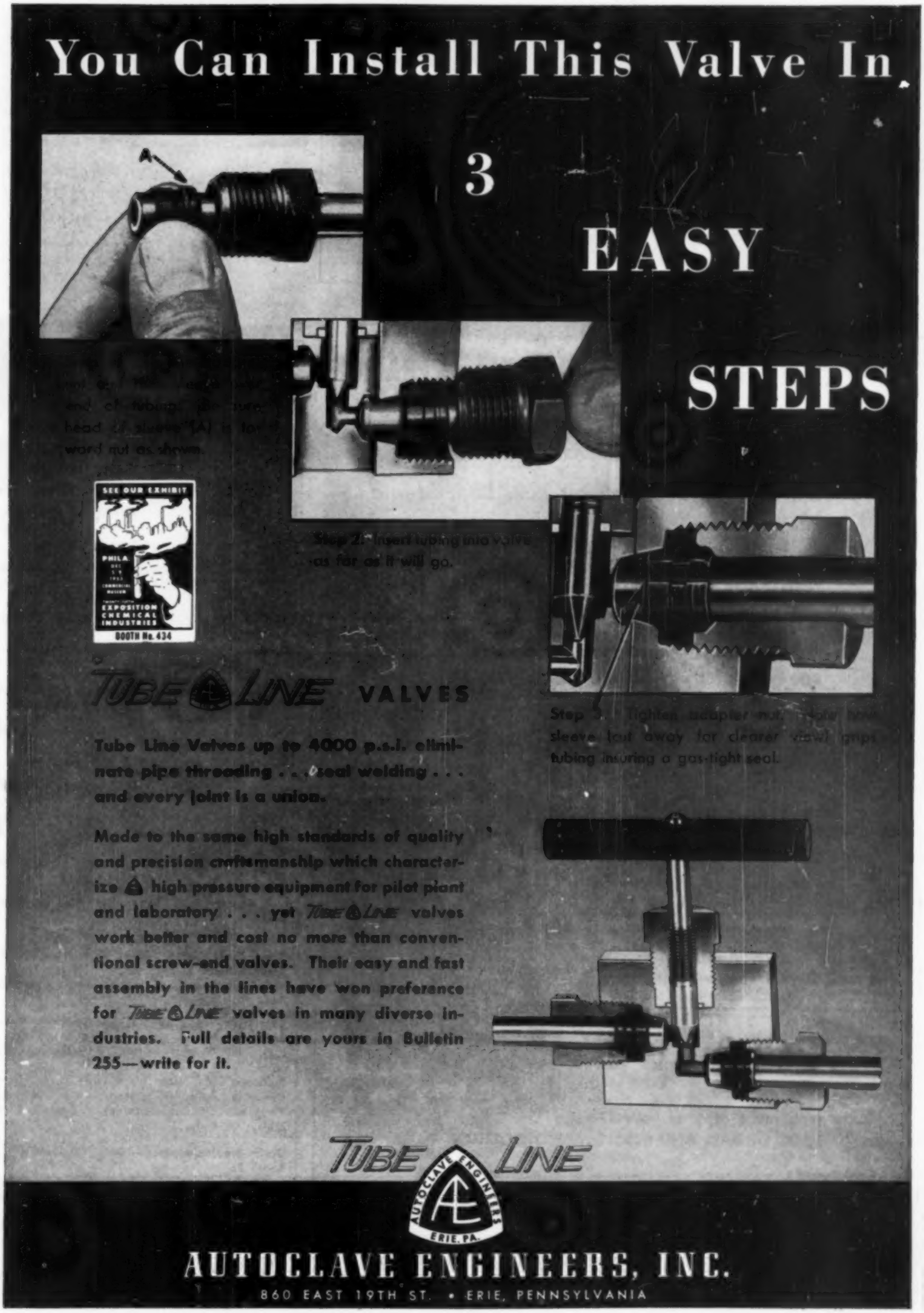
Gabb Special Products, Windsor Locks, Conn. Booth C-122
D.S. 78—Shear-Flow ¾ h.p. portable mixer, has 2 impellers & stator .005 in. apart. Mixes, homogenizes, disperses.
Bulletins: Illustrated data sheet.
Personnel: D. H. Thomson, pres.; G. S. Chiaramonte, genl. sales mgr.; R. P. Genovesi, adver. mgr.

Garlock Packing Co., Palmyra, N. Y. Booth 405
D.S. 79—Teflon, Kel-F & silicone mechanical packings & seals.
Bulletins: Cat. on forms & dimensions of packings & gaskets. Section on applications.
Personnel: J. B. Sewell, v.p.; C. F. Palmer, dist. mgr.; R. C. Shaw; L. B. Snyder; R. W. Halpin; W. J. Lauter; F. Wilders.

General Alloys Co., Boston, Mass. Booth 748

General American Trans. Corp., Chicago, Ill. Booth 42-44
D.S. 80—Rotary disc contactor for liquid-

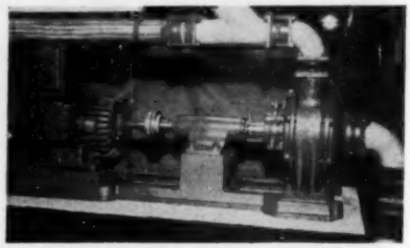
(Continued on page 84)



You Can Install This Valve In
3
EASY
STEPS
end of tubing. Be sure
head of sleeve (A) is to-
ward nut as shown.
Step 2: Insert tubing into valve
as far as it will go.
Step 3. Tighten adapter nut.
sleeve (cut away for clearer view) grips
tubing insuring a gas-tight seal.
SEE OUR EXHIBIT
PHILA
EXPOSITION
CHEMICAL
INDUSTRIES
BOOTH No. 434
TUBE LINE VALVES
Tube Line Valves up to 4000 p.s.i. eliminate pipe threading . . . seal welding . . . and every joint is a union.
Made to the same high standards of quality and precision craftsmanship which characterize high pressure equipment for pilot plant and laboratory . . . yet TUBE LINE valves work better and cost no more than conventional screw-end valves. Their easy and fast assembly in the lines have won preference for TUBE LINE valves in many diverse industries. Full details are yours in Bulletin 255—write for it.
TUBE LINE
AUTOCLAVE ENGINEERS ERIE, PA.
AUTOCLAVE ENGINEERS, INC.
860 EAST 19TH ST. • ERIE, PENNSYLVANIA

liquid & solid-liquid. Model of Airslide hopper car shows operating principles; also modern tank storage terminal handling bulk shipments.
Bulletins: Detailed catalog on each product mfrd.
Personnel: H. D. Skyrm, v.p. sales; J. P. McFadden, v.p. Tank Car; S. D. Moseley, asst. to pres.; E. J. Lyons, genl. mgr. Turbo-Mixer; J. R. Scanlin, asst. to v.p. Tank Car; G. Gutzeit, dir. res. & dev.

Gen. Ceramics & Steatite Corp., Keasbey, N. J.
D.S. 81—New chemical alumina (ceramic as strong as cast iron) equipment shown in pumps, valves, pipe & fittings. Also chemical stoneware, porcelain, & glass lined equip.



Bulletins: 16-p. catalog detailing product line.
Personnel: W. D. Kleppinger, v.p.; C. E. Eisenmann, sales engr.; K. J. Peter, consult.

General Elec. Co., Schenectady, N. Y. Booth 850
Electrical equipment for process plant power and control.

General Lead Constr. Corp., Kearny, N. J. Booth C-27
Fabricated vessels.

Girdler Co., The, Louisville, Ky. Booth 45
Catalysts; Votator units; process plants engineered & constructed by Gas Processes Div.

Glascote Products, Inc., Cleveland, O. Booth 106 (See A. O. Smith Co.)
Glass-lined steel process plant equipment.

Glengarry Equipment Corp., Bay Shore, N. Y. Booth 514
D.S. 82—Gravimetric & volumetric weighing & proportioning equip. for handling dry & liquid matls.
Bulletins: Technical data sheets on each unit plus illustrated bulletins on weigh-feeders.

Gould Pumps, Inc., Seneca Falls, N. Y. Booth C-168
Centrifugal pumps

Great Lakes Carbon Corp., New York, N. Y. Booth 306-308
Graphite electrodes, anodes, molds & specialties.

Great Western Mfg. Co., Leavenworth, Kans. Booth 741-743
D.S. 83—Gyratory sifting & screening machines.
Bulletins: Data folder on HS free swing sifter; complete catalog on gyratory motion machines.
Personnel: J. E. Baker, partner; R. Bunnell; R. N. Bailey; G. Bailey.

Greif Bros. Cooperage Corp., Delaware, O. Booth 76
D.S. 84—Containers: fibre & steel drums, wood barrels, & plywood drums (also available for glass or polyethylene carboy).
Bulletins: 4-way bulk package brochure; Folder on new SS/SF Carpenter Lok-Rim fibre drum.
Personnel: F. K. Duffy, exec. asst.; plant engrs.

(Continued on page 86)

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Grinnell Co., Inc., Providence, R. I. Booth 50
Grinnell-Saunders diaphragm valves.

Grip-Strut Division, Chicago, Ill. Booth 735-737
(See The Globe Co.)

Gross Co., F. R., Akron, Ohio. Booth C-137
D.S. 85—Insert for hollow condensate-channeling cooling rolls.
Bulletins: Technical folder gives over-all heat transfer improvement data.
Personnel: F. R. Gross.

Gump Co., B. F., Chicago, Ill. Booth 23
D.S. 86—Equip. for dry feeding, mixing, packing, sifting, grading and weighing.
Bulletins: New booklet on Bar-Nun rotary sifters gives specs., oper. data, install photos.
Personnel: R. E. Williams, pres.; D. E. Stage, v.p.; A. W. Patzlaff; W. W. Grieb.

Hamer Valves, Inc., Long Beach, Calif. Booth C-123—C-127
D.S. 87—New lines of gate valves featuring improved wedge & seat design assuring tight seal & new visible-wedge valves. Also line of blind & plug valves.
Bulletins: Cat. sheet on visible wedge valves details operating features; another on gate valve shows design features.
Personnel: C. P. Williamson, sales mgr.; H. E. Maland, R. W. Sexton, Jr.

Hamilton Mfg. Co., Two Rivers, Wis. Booth C-161
D.S. 88—Steel & wood lab. furniture.
Bulletins: 36-p. selector's catalog of line.
Personnel: A. R. Salveson, Sales mgr. lab.; G. M. O'Brien; T. R. Daly, spec. consult. steel; G. Nagler.

Hanovia Chemical & Mfg. Co., Newark, N. J. Booth C-17-19-21
Ultraviolet sources.

Harbison-Walker Refrac. Co., Pittsburgh, Pa. Booth 917
Refractories, acid brick, mortars.

Hardinge Mfg. Co., York, Pa. Booth 4
Rotating-vessel mills, horizontal bed filters, wet classification units.

Harman Associates, Long Is., N. Y. Booth 715

Hart-Carter Co., Minneapolis, Minn. Booth C-18
D.S. 89—Disc separator type dry separator for length sizing. Also precision grader for thick. & width sizing.
Bulletins: Length classification of granular matls.; Carter Precision Grader; Applications.
Personnel: H. Shepardson, sales mgr.; E. O. Anderson; M. C. Cecka; F. X. Dubay.

Haveg Corp., Newark, Del. Booth 534
Corrosion-resisting process plant equipment of phenolic-reinforced asbestos, polyester reinforced fiberglass, etc.

Haynes Stellite Co., New York, N. Y. Booth 350
Corrosion- and heat-resisting alloys.

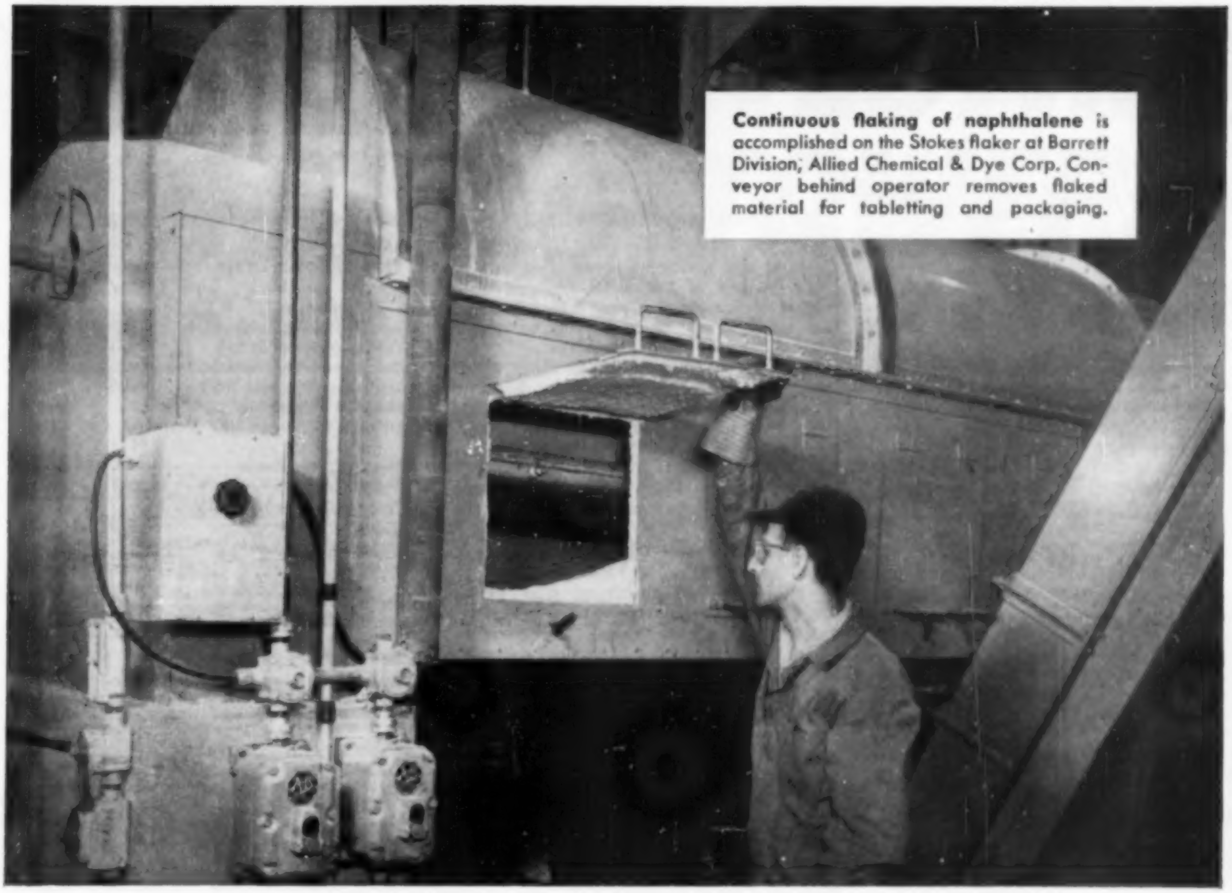
Heil Process Equip. Corp., Cleveland, O. Booth 622-624

Hercules Filter Corp., Hawthorne, N. J. Booth 78
D.S. 90—Self-cleaning Rotojet & manual cleaning Rapidor pressure leaf filters. Steel, s.s., monel. Also all-plastic sheet filter.
Bulletins: New genl. cat. on pressure leaf filters.
Personnel: C. E. Hunziker, pres.; H. T. Jones, Jr., v.p.; R. Zust; G. Zebora; V. Tozzi; E. Daly.

Hermes Mach. Co., Hawthorne, N.J. Booth C-117

Hewitt-Robins Inc., Stamford, Conn. Booth C-14
Belt conveying systems & units; hose.

(*Continued on page 90*)



Continuous flaking of naphthalene is accomplished on the Stokes flaker at Barrett Division, Allied Chemical & Dye Corp. Conveyor behind operator removes flaked material for tabletting and packaging.

Barrett improves quality, cuts costs in naphthalene production

Purity is higher, costs lower with continuous flaking process. Flaked naphthalene is compressed into balls or rings, with the aid of Stokes tabletting machines.

Stokes flaker replaces batch method in the processing of moth-killing chemical

Marketed in flakes, balls and handy rings which slip over the hook of coat-hangers, naphthalene is the housewife's friend—and the moth's worst enemy.

At the Barrett Division of Allied Chemical & Dye Corp., molten naphthalene at 194°F. is fed to a Stokes single drum flaker where the material crystallizes on the revolving drum. The solidified naphthalene is removed by a doctor blade at 72°F. in quantities ranging up to 1500 pounds per hour. Subsequent tabletting operations on Stokes tablet machines produce finished moth balls and rings.

Before purchasing the flaker, Barrett called on the Stokes Advisory Service and Laboratory for recommendations. Tests in the Stokes Laboratory determined the appropriate drum temperature, rotating speed and size of the unit required to give desired production. Similar tests have preceded the design of flakers for wax, insecticides, resins, many chemical intermediates and other products suited for high capacity flaking.

Stokes makes its broad experience in all phases of chemical processing available to manufacturers through this well-staffed Laboratory and Advisory Service. Full details of this laboratory and advisory service for the solution of production problems are covered in Bulletin 640.

Send for this booklet as well as an informative brochure on Stokes equipment for the Chemical & Processing Industries. F. J. Stokes Machine Company, Philadelphia 20, Pa.

STOKES

ORGANIC COATINGS INDICATOR CHART

Part IV

Kenneth Tator | Kenneth Tator Associates, Coraopolis, Pa.

ASPHALT

Asphalts basically have higher moisture transmission than the coal tars, but unlike the coal tars do not have the same tendency to "alligator" on exposure to direct sunlight, weather, or heat. The asphalt materials are preferred protectors within this group for protection of steel in weathering exposures.

COAL TARS

The coal tars possess extremely high resistance to moisture transmission but poor resistance to direct exposure to sunlight, weather, and heat; initiation of the failure from such exposures becoming evident by "alligatoring." Preferred usage of coal-tar coatings therefore are in highly humid or wet exposures in sheltered applications. Protection of structures below ground, under water, or in basement applications are successful.

WAX AND GREASE

Wax and grease type of coatings in performance follow closely that of the bitumins. These materials will "alligator" like the coal tars on continuous exposure to direct sunlight and heat. Due to their nature they are difficult to over-coat satisfactorily with coating materials of other types. Predominantly used for low-cost temporary corrosion protection of metals.

VINYLIDINE CHLORIDE

These saran-based coatings are predominantly available today as dispersion coatings, and this fact in large part accounts for their greater moisture transmission and the thinness of application. Basically, these materials should present resistances comparable or exceeding these of the vinyl chloracetates and it is felt that when solvent solutions of these resins are generally available, these potentials will be realized.

BUTADIENE STYRENE

These synthetic rubber related resins are comparable in formulation and performance to the chlorinated rubbers, and as such constitute excellent protection for concrete and masonry constructions.

Conclusions

This concludes explanatory material on the Organic Coatings Indicator Chart. Part I was run in the August issue, page 40 and part II in the September issue, page 78.

Kenneth Tator, the author of this series of articles, is the subject of a personalia item in this issue.

No. 50

CARBON-IMPREGNATED GRAPHITE REFERENCE SHEET

Myron Cory | Graphite Specialties Corporation, Niagara Falls, N. Y.

Graphite having its pores filled with carbon instead of the usual resin is a new basic material of construction suited to applications of more severe temperature and chemical agent exposure.

Graph-i-tite is the trade name of this material produced by Graphite Specialties Corp. Grade A can be used up to 5800° F., but becomes slightly permeable to air at 40 lb./sq.in. at 1350° F. Grade A is less permeable to air than Grade G, until it has been heated to 5800° F., at which temperature the two materials are identical.

FORMS

Graph-i-tite carbon-impregnated graphite is currently being produced in a variety of shapes and sizes ranging up to 22-in. diameter and 9-ft. length. Originally produced as extruded tubes, it is now available in forms for towers, heat exchangers, absorbers, crucibles, boats, nozzles, molds, and specialty products.

SERVICE REPORTS:

Graphite Specialties Corp. has supplied a Graph-i-tite chlorinator which has been held above 3500° F. for over two months and has remained in useable condition. Graph-i-tite grade A pipe has been in 35% hypochlorite solution for over one month with no weight loss due to chemical attack. Graphite Specialties believes Graph-i-tite to have the necessary properties for use in the circulating liquid metal atomic reactors, for two-fold use as piping and moderator. To date, Graph-i-tite has not been made of sufficient purity for atomic pile usage, but it appears sufficient purification can be accomplished upon installation of necessary equipment.

MEANS FOR MAKING JOINTS:

There being no cements currently available which are capable of approaching the permissible upper temperature limits of carbon-impregnated graphite, the following measures have been adopted for securing joints:

Applications below 450° F: Graphite Specialties makes use of Teflon gaskets.

Applications above 450° F: In some cases it is possible to use Teflon gaskets by keeping the Teflon near the extremities of the flanges, or through use of cooling jackets. Either of these measures should keep the Teflon below 450° F.

If either of the above methods for protecting the Teflon are impractical, Graphite Specialties resorts to the use of a somewhat tedious assembly of a tongue and groove joint. An unctuous graphite powder is compacted in the groove and held under compression with the tongue of the joint.

Liquid-tight but not air-tight joints are made by careful threading and then dusting the threads with a special very fine graphite powder.

The development of other means for securing joints is currently receiving active attention.

PHYSICAL PROPERTIES

Properties	"Graph-I-Tite" A	"Graph-I-Tite" G
Apparent Density (lb./ft.³)	116	114
Tensile Strength (PSI)	2700	2400
Compressive Strength (PSI)	9000	8500
Transverse Strength (PSI)	4700	4300
Modulus of Elasticity (x 10^6)	21	18
Thermal Expansion (In/In/° F. x 10^{-7})	11	9
Electrical Resistance (ohm-inches)	.00043	.00034
Thermal Conductivity (BTU/sq.ft./° F./hr/in)	1000	1100
Maximum Temperature Resistance	See paragraph top left	5700° F.

CHEMICAL PROPERTIES

Chemical Reagent	Concentration	Temperatures
Acids		
Acetic Acid	All	Boiling
Formic Acid	All	Boiling
Hydrobromic Acid	All	Boiling
Hydrochloric Acid	All	Boiling
Hydrofluoric Acid	0-48%	Boiling
Hydrofluoric Acid	48-60%	185° F.
Monochloracetic Acid	100%	Boiling
Nitric Acid	0-20%	175° F.
Oxalic Acid	All	Boiling
Phosphoric Acid	All	Boiling
Sulfuric Acid	0-75%	Boiling
Alkalies		
Ammonium Hydroxide	All	Boiling
Monethanolamine	All	Boiling
Sodium Hydroxide	All	Boiling
Salt Solutions		
Ferric Chloride	All	Boiling
Ferrous Chloride	All	Boiling
Ferrous Sulfate	All	Boiling
Nickel Chloride	All	Boiling
Nickel Sulfate	All	Boiling
Sodium Hypochlorite	0-35%	150° F.
Zinc Chloride	All	Boiling
Zinc Sulfate	All	Boiling
Halogens, Air		
Air	——	750° F.
Dry Chlorine	100%	5800° F.
Organic Compounds		
Acetone	100%	Boiling
Benzene	100%	Boiling
Carbon Tetrachloride	100%	Boiling
Chlorethylbenzene	100%	250° F.
Chloroform	100%	Boiling
Ethyl Alcohol	All	Boiling
Ethylene Dibromide	100%	200° F.
Ethylene Dichloride	100%	Boiling
Gasoline	100%	Boiling
Glycerine	100%	Boiling
Isopropyl Alcohol	100%	Boiling
Isopropyl Ether	100%	Boiling
Kerosene	100%	Boiling
Mannitol	All	Boiling
Methyl Alcohol	100%	Boiling
Monochloro Benzene	100%	Boiling
Trichlorethylene	100%	Boiling

No. 51

MARLEY IS TESTING COOLING TOWERS

AND HERE IS THE RECORD

TEST NO.	TYPE OF SERVICE AND LOCATION	SPECIFIED CONDITIONS				TEST RESULT	
		Gallons Per Minute	Hot Water Temp.	Cold Water Temp.	Wet Bulb Temp.	[1]Degrees Cold Water Temp.	[1]Percent Capacity
1	Air Conditioning—West Coast	400	90°	80°	70°	+0.80°	+9.4%
2	Air Conditioning—Gulf Coast	6,500	101.3°	88.5°	80°	—0.40°	—4.3%
3	Chemical Plant—East Coast	18,500	104°	89°	76°	+0.50°	+3.8%
4	Chemical Plant—East Coast (1 of 4 duplicate units)	27,500	103°	88°	76°	—0.40°	—3.2%
5	Power Plant—Southwest	57,500	109.6°	92.6°	78°	—0.04°	—0.4%
6	Petroleum Refinery—Gulf Coast	3,400	115°	80°	70°	+0.90°	+8.5%
7	Power Plant—South Central	83,000	108.1°	90°	76°	—0.04°	—0.4%
8	Power Plant—Mountain States	45,000	105°	83.7°	63°	+0.20°	+0.8%
9	Petroleum Refinery—Gulf Coast	15,000	111°	90°	82.5°	+0.70°	+7.7%
10	Petroleum Refinery—Gulf Coast	36,570	120°	90°	82°	—0.60°	—4.4%
11	Power Plant—Southwest	70,450	102.6°	86°	70°	—0.86°	—4.4%
12	Power Plant—Southwest	70,450	102.6°	86°	70°	—0.51°	—2.7%
13[2]	Power Plant—East Central	13,000	101°	85°	75°	—3.70°	—24.3%
14	Power Plant—Mid-Central	44,000	100°	86°	74°	+0.45°	+4.0%
15	Power Plant—South Central	83,000	108.1°	90°	76°	—0.80°	—4.3%
16	Chemical Plant—South	40,000	103.3°	85°	78°	—0.30	—3.0%
17	Power Plant—North Central	37,000	100.5°	83°	72°	+1.20°	+9.6%
18	Petroleum Refinery—East Coast	15,570	115°	85°	76°	+1.10°	+9.0%
19	Power Plant—Mountain States	65,000	101.7°	82°	63°	+0.78°	+4.1%
20	Chemical Plant—Gulf Coast	40,750	123°	90°	80°	—0.16°	—1.2%
21	Chemical Plant—Gulf Coast	11,000	116°	90°	80°	+1.80°	+13.2%
22[3]	Retest of Tower Reported in No. 14	44,000	100°	86°	74°	+0.45°	+4.0%
23[4]	Retest of Tower Reported in No. 11	70,450	102.6°	86°	70°	+0.20°	+1.1%
24[4]	Retest of Tower Reported in No. 12	70,450	102.6°	86°	70°	+0.33°	+1.8%
25	Petroleum Refinery—East Central	6,000	125°	90°	75°	—0.46°	—2.6%
26[5]	Petroleum Refinery—Gulf Coast	10,000	120°	85°	79°	+0.30°	+3.2%
27	Power Plant—Southwest	72,000	112°	92°	78°	+1.05°	+6.6%
28	AEC—East Central (1 of 2 duplicate units)	62,798	132.3°	90°	80°	+0.31°	+3.5%

NOTES: 1) Plus indicates capacity exceeding specified performance; minus denotes deficiency. 2) Tested to determine loss of performance due to extensive settling of basin and resultant misalignment of structure. 3) Retested at higher wet bulb. 4) Retested at contract (higher) horsepower. 5) Tested in accordance with Cooling Tower Institute test procedure (ATP-105 adopted May 1, 1955) and observed by CTI representative.

HERE IS THE RECORD — a consecutive list of ALL acceptance tests conducted by Marley during the 1954-1955 test seasons. All are full-scale tests conducted in strict accordance with specified methods.

Towers tested were of many sizes and capacities, operating under widely varying conditions. Geographically, these tests spanned the entire country and included towers sold since 1950, located at elevations up to 5,000 feet.

HERE IS THE RECORD that offers **more positive assurance of performance satisfaction than any guarantee ever written.** It shows why Marley has the complete confidence to insist that you TEST YOUR TOWER.

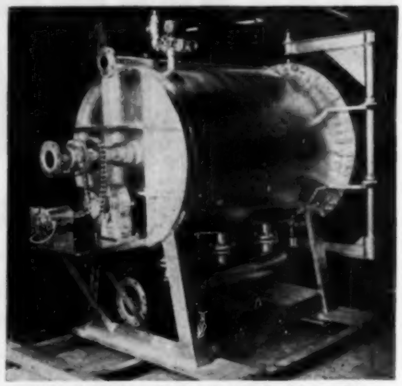
MARLEY

The Marley Company

Founder-Member Cooling Tower Institute

Kansas City, Missouri

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION



Hercules Filter Corp. See D.S. 90, p. 86.

Heyl & Patterson, Inc., Pitts., Pa. Booth 226
D.S. 91—Reineveld test centrifugal 16-in. diam.; 3-in. liquid cyclones for solids classification & thickening.
Bulletins: Cat. 20-p. covering applications of liquid cyclones. Flowsheets.
Personnel: E. H. D. Gibbs, v.p. sales; E. J. O'Brien, sales mgr.; J. H. Farnsworth; R. D. Lloyd; W. T. Hollins; H. V. White.

High Press. Equip. Co., Inc., Erie, Pa. Booth 717

Hills-McCanna Co., Chicago, Ill. Booth 222
Saunders diaphragm valves, proportioning pumps.

Hinckley Corp., Belmont, Mass. Booth 745

Herman Hockmeyer & Co., New York, N. Y. Booth C-61

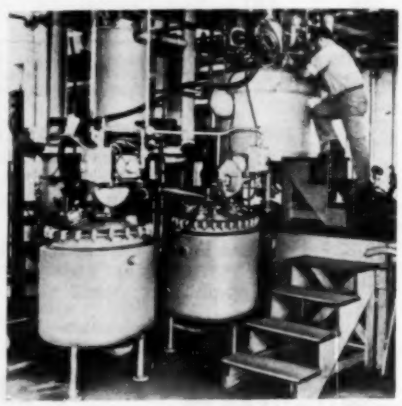
Hoke, Inc., Englewood, N. J. Booth 935
D.S. 92—Small valves. New brass bellows valve (small packless valve).
Bulletins: Bull. NV-555—new—on needle valves. Valve selector wall chart with dimensional data.
Personnel: W. O. Teeters, pres.; D. B. Salmon, v.p.; E. B. Hitchcock, sales mgr.; R. MacLallen; S. Jones; W. Calahan.

Homestead Valve & Mfg. Co., Coraopolis, Pa. Booth S-38, S-77
Plug valves.

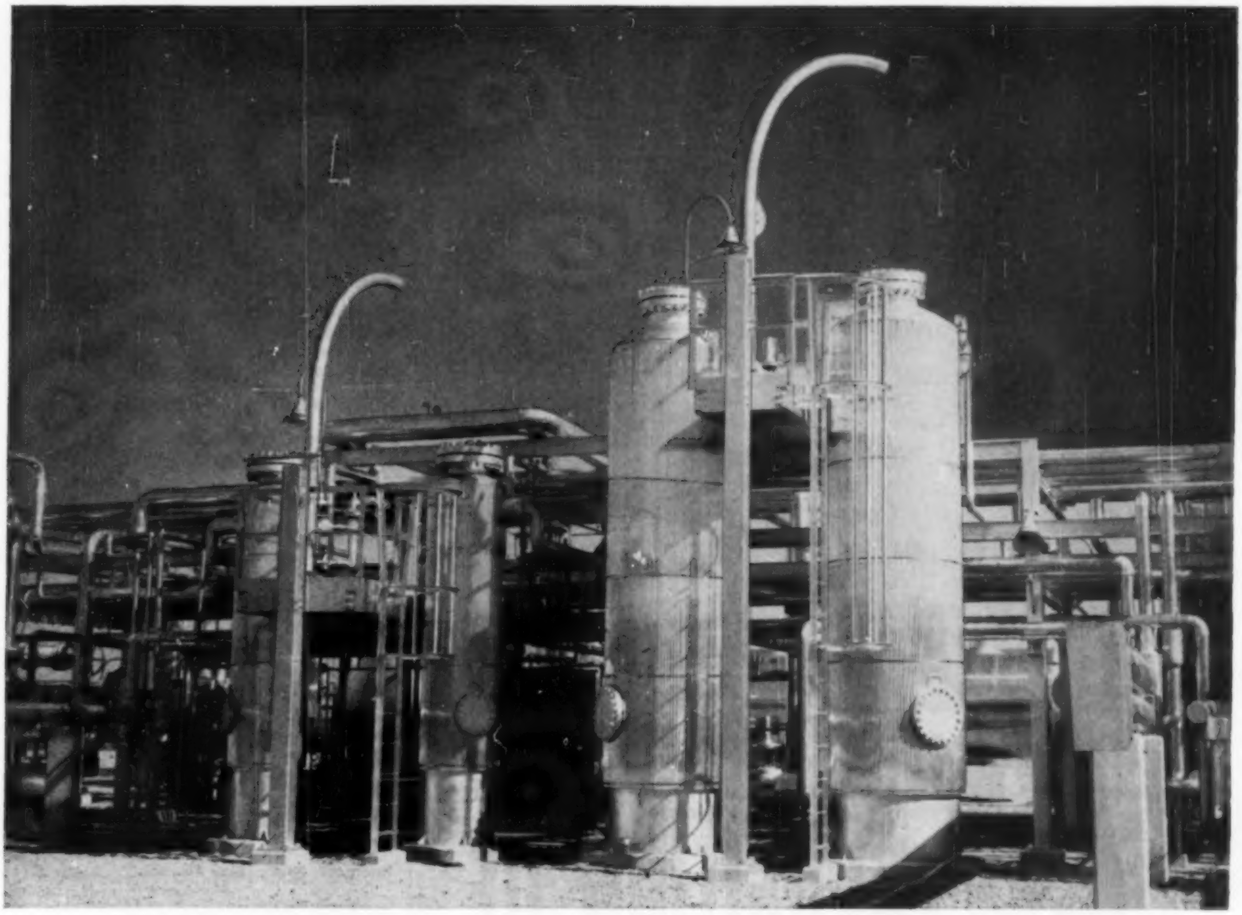
Howe Scale Co., The, Rutland, Vt. Booth 322

Hungerford & Terry, Inc., Clayton, N. J. Booth 205

Hunt Machine Co., Rodney, Orange, Mass. Booth 821
D.S. 93—Turba-Film (turbulent-film) evaporators, Rodney Hunt—Luwa spray dryers.



(Continued on page 92)



Unibestos makes the big difference in pipe insulation for chemical plants

Not all pipe insulation is alike. There's a difference in insulating capacity . . . in durability . . . in ease of installation. And more and more chemical plants find Unibestos pays off on all three points. For Unibestos is made of Amosite, the long-fiber, quality asbestos that permits single-layer construction with superior insulating properties.

Single-layer Unibestos is easily installed right on the job. It's a strong, long-lasting insulation that withstands vibration and shock . . . resists moisture, steam, acid and chemical fumes. In fact, durable Unibestos is so durable that it can be removed and re-used many times over. Unibestos® pipe insulation is available in sectional form through 44" O.D.

Joe Bestos says:

Unibestos fits to a tee! . . . or to joints or other fittings. Remember, Unibestos is easy to cut, miter or groove . . . goes on faster with no fuss or muss.

Write for **Free** descriptive Bulletin 109C.

UNARCO

UNION ASBESTOS & RUBBER COMPANY

1111 West Perry Street • Bloomington, Illinois

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Bulletins: New literature will contain construction & operating data on these Turba-Film evaporators.
Personnel: M. Coston, mgr. proc. equip.; E. S. Harris; others.

Hydroco Division, Cleveland, O. Booth 333-335
(See New York Air Brake Co.)

Illinois Water Treatment Co., Rockford, Ill. Booth 630
Ion exchangers for process solution clarification & water demineralization.

Imperial Brass Mfg. Co., Chi., Ill. Booth 439-441

Industrial Div. Phil., Pa. Booth 531
(See Minneapolis-Honeywell Regulator Co.)

Industrial Filter & Pump Mfg. Co., Chicago, Ill. Booth 51-53
Clarifying filters, centrifugal pumps, ion exchangers, heat exchangers and rubber lining services.

Industrial Labs. Pub. Co., Chi., Ill. Booth C-149

Industrial Steels Inc., Cambridge, Mass. Booth 726

Ingersoll-Rand Co., New York, N. Y. Booth 918
Process gas & air compressors, centrifugal pumps, engines.

Insul-Mastic Corp. of Amer., Pittsburgh, Pa. Booth 444

International Boiler Wks. Co., Stroudsburg, Pa. Booth 548

Internat'l. Engrg. Inc., Dayton, O. Booth C-114
Dry solids size reduction & blending equip.; top & side entering liquid mixers.

International Nickel Co., Inc., New York, N. Y. Booth 507
D.S. 94—Ni-o-nel. A new corros.-resis. high-nickel alloy. Also new Ductile Ni-Resist; latest Inco development in cast metals.
Bulletins: Technical data sheets & reprints on properties and applications service.
Personnel: J. W. Carey, asst. sect. hd., chem. sect.; G. Gladis.

Jabsco Pump Co., Burbank, Calif. Booth 328
D.S. 95—Small, rotary, self-priming, pumps with neoprene impeller. Models in s.s., bronze, c.i., plastic.

Jacoby-Tarbox Corp., Yonkers, N. Y. Booth 632
Sight-flow indicators.

Janney Cylinder Co., Phila., Pa. Booth 132

Jarrell-Ash Co., Newtonville, Mass. Booth C-164

Jeffrey Mfg. Co., Columbus, Ohio. Booth 201
D.S. 96a—New drum-type dryer; LMV lightweight conveyor section; HMV mechanical vibrating conveyor similar but handling larger tonnages; Waytrol gravimetric feeder; elec. vibrating-pan feeders; & swing-hammer pulverizer.
Bulletins: Catalog data sheets on all products displayed.

Jenkins Bros., New York, N. Y. Booth 147

Jerguson Gage & Valve Co., Somerville, Mass. Booth C-132
D.S. 96b—Elec. htd. gauges & valves; Kel-F lined flow glasses; reflex gauges with photo-elec. cell for high-low level control; external prism gauges for b. & w. readings regardless of liquid color.

(*Continued on page* 94)

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Bulletins: 8-p. condensed cat. on liq. level gauges & valves; data sheet on No. 23 self-draining valve; also on sight flow indicators.
Personnel: J. A. Ford, v.p.; E. E. van Ham, v.p.; R. S. Stanley, asst. chf. engr.; L. A. Martel.

Johns-Manville Sales Corp., New York, N. Y. Booth 508
Insulations, Transite pipe, packings & gaskets.

Kanigan Div., Chicago, Ill. Booth 42-44
(See General Amer. Trans. Corp.)

Kathabar Div., Toledo, Ohio. Booth 54
(See Surface Combustion Corp.)

Kellogg Co., The M.W., New York, N. Y. Booth 835-839-843
Kel-F polymers, Engineering & construction services

Kewaunee Mfg. Co., Adrian, Mich. Booth 707
D.S. 97—Laboratory furniture. A complete lab. will be displayed.
Bulletins: Selection data for air flow fume hoods. New catalog on gloved box operations.
Personnel: E. A. Moudry, genl. sales mgr.; J. A. Peay; W. Miller; A. J. Flory.

Kimble Glass Co., Toledo, Ohio. Booth 408
D.S. 98—Special laboratory ware.
Bulletins: Catalog covering genl. lab. ware line.
Personnel: E. J. Rhein, sales mgr.; J. F. Ryley, asst. sales mgr.; J. J. Moran.

Kinetic Disp. Corp., Buffalo, N. Y. Booth C-118

Kinney Mfg. Co., Boston, Mass. Booth 333-335
Vacuum and pos. disp. liquid pumps.

Knapp Mills, Inc., Long Is. City, N. Y. Booth 19
D.S. 99—Fabrications (equipment & piping) from lead clad steel & ld. clad copper. Introducing new Alumilum lead clad aluminum which combines corrosion resistance of lead with light wt., elec. props., & high heat transfer values of aluminum.
Bulletins: 32-p. design cat. on lead clad metals with dimensions, ratings, etc. of standard products. Also field construction of lead and rigid PVC equip.
Personnel: J. E. English, v.p. sales; N. Ritchey, res. dir.; J. H. Ewing, mgr. specs. div.; T. Tschudi, chf. des. engr.

Knight, Maurice A., Akron, Ohio. Booth 7
Ceramic and plastic acid- and halogen-resistant equipment.

Komline-Sanderson Engrg. Corp., Peapack, N. J. Booth C-151

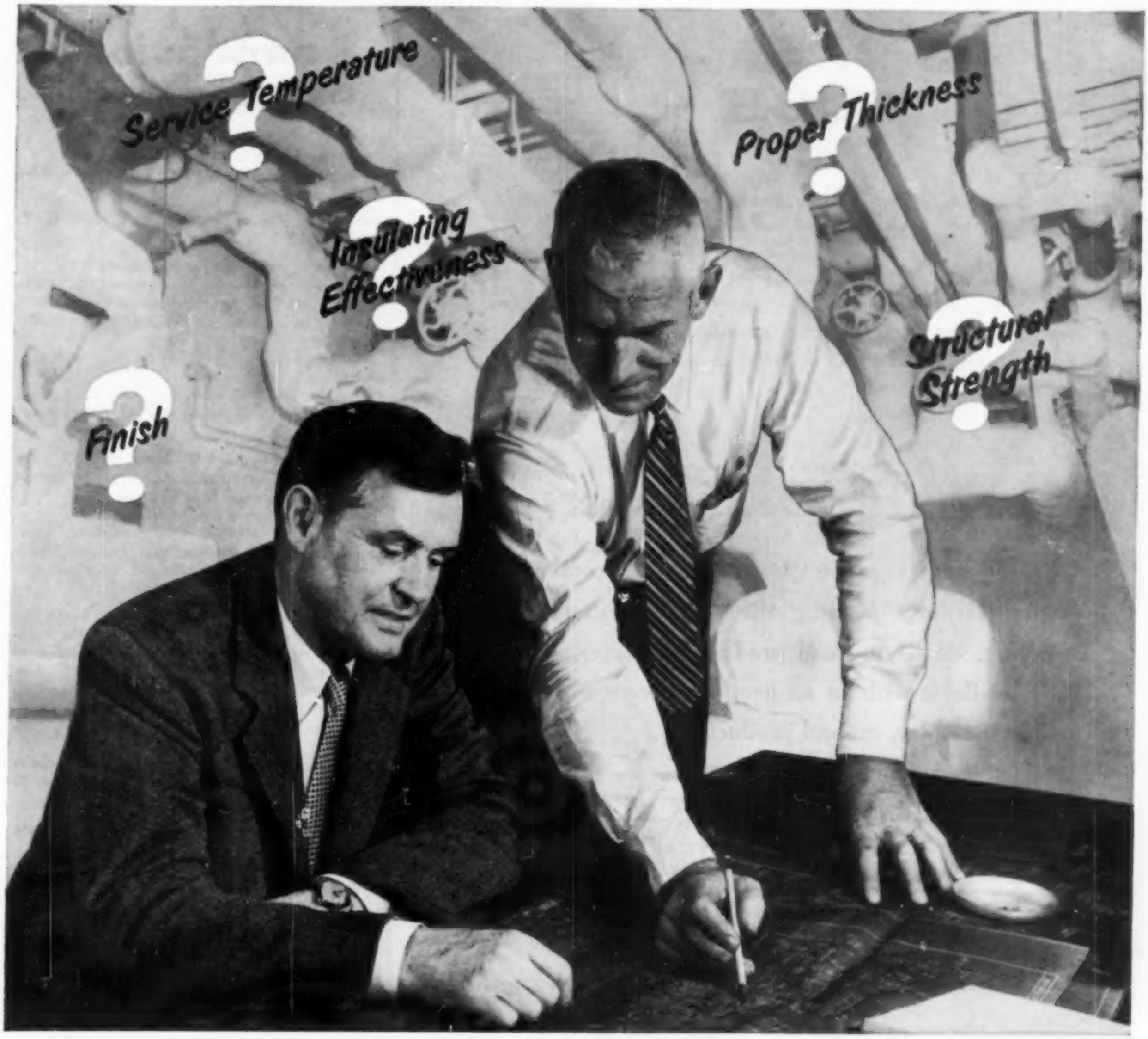
Kontes Glass Co., Vineland, N. J. Booth C-154
D.S. 100—Laboratory glassware.
Bulletins: Vacuum gauges; precis. stirrers (8-p.)
Personnel: W. C. Kontes, partner; S. Guerra; C. D. Federline, sales prom. mgr.

Koven & Brother, Inc., L. O., Jersey City, N. J. Booth 834
Fabricated vessel equipment; standard tanks.

Laboratory Equip. Corp., St. Joseph, Mich. Booth C-124
D.S. 101—Leco high frequency combustion app. for anal. of sulfur in oil & oil additives.
Bulletins: 6-p. technical guide to S analysis.
Personnel: H. J. Schmitt, genl. sales mgr.; W. E. Stockwell; D. J. Anderson; A. E. Borrelli; O. R. Siewert; E. L. Bennet, res. & devel.

Laboratory Furn. Co., Inc., Mineola, N. Y., Booth 414
D.S. 102—Endurock lab. table surface material.

(Continued on page 96)


Service Temperature
Proper Thickness
Insulating Effectiveness
Structural Strength
Finish

Bulletins: Giving independent test report.
Personnel: J. M. Liptay, pres.; R. H. Elmore, v.p.; E. Hill, genl. mgr.

Laboratory Glass Supply Co., New York, N. Y. Booth C-135

LaBour Co., Inc., Elkhart, Ind. Booth 31
D.S. 103—First showing of type "CG" packingless centrifugal chemical pump. Self-priming vertical—for both flooded suction & suction lift. Also other types.
Bulletins: Binder of detailed catalogs with C.S. drwgs., rating data, etc.
Personnel: W. A. Schumacher, sales mgr.; M. S. Maleson; J. C. Reynolds; W. K. Sims; M. E. Toney.

Ladish Co., Kenosha, Wis. Booth 26
D.S. 104—Centrifugal pumps, welding fittings & valves. Magnetic traps & filters.
Bulletins: On above products.
Personnel: F. Hinrichs, v.p.; T. LaRose, genl. sales mgr.; F. W. Hinrichs, east. mgr.; E. Stephenson; W. Glass; J. Kessler, chf. engr.; R. Nissen, sales prom. mgr.

Lapp Insulator Co., Inc., LeRoy, N. Y. Booth 814
D.S. 105—New Microflo Pulsafeeder diaphragm proportioning pump for capacities to 2,300 cc./hr. at press. to 200 lb./sq.in.g. Also a diaphragm type gas compressor for handling gases without contamination. Tower packings.
Bulletins: Pulsafeeder specs., with inquiry data sheet.
Personnel: W. V. Lapp, treas.; L. F. Wilson, sales mgr.; V. Leipold; R. P. Wickins; G. Whittet; D. G. Williams.

Lawrence Pumps, Inc., Lawrence, Mass. Booth 320-322
D.S. 106—A PVC plastic pump with nonmetallic mechanical seal. Axial flow propeller pump for large vols. against low hds.
Bulletins: No. 203-7 a loose-leaf binder insert with cross-sect. draws., specs., etc.
Personnel: V. J. Mill, chf. engr.; V. J. Mill, Jr., sales mgr.

Lead Lined Iron Pipe Co., Wakefield, Mass. Booth 210
Lead lined pipe and valves.

Lebanon Steel Fdry., Lebanon, Pa. Booth 134
D.S. 107—Castings of carbon, low alloy & s.s.
Bulletins: Ceramicast, which uses ceramic molds for precision castings of smooth surfaces.
Personnel: W. H. Worrilow, v. p. sales; J. H. Boyd, genl. sales mgr.; A. W. Blecker; E. H. Platz, Jr.

Leeds & Northrup Co., Phila., Pa. Booth 734
Process control systems & apparatus.

Lehmann Co., Inc., J. M., Lyndhurst, N. J. Booth C-42
D.S. 108—Dispersion, grinding & mixing equipment. Roller, pulverizing & stone mills. Emulsifiers, etc.
Bulletins: Russell Constrs. Ltd. (London) infinitely variable speed sieving unit. Tech. data sheet on 450-gal. paddle-type paste mixer.
Personnel: C. B. Hoffman, sales mgr.; J. M. Sarlat; H. Mierswa; C. Dittmann; C. G. Page; H. F. Croot, dir. sales Thropp div.; W. Wilkes.

Leslie Co., Lyndhurst, N. J. Booth C-31
D.S. 109—Control valves. Temperature controllers & pressure regulators.
Bulletins: More than 100 pages of technical data bulletins on control valves & floatless liquid level control.

(*Continued on page* 98)

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Personnel: J. S. Leslie, pres.; R. W. Boettiger, sales mgr.; H. A. Frederick; A. J. Dromm; J. R. Bermingham; E. Elliott.

Link-Belt Co., Chicago, Ill. Booth 532
D.S. 110—Operating Roto-Louvre dryer; Bulk-Flo conveyor system; & a liquid vibrating screen with recycling system. Also power transmission acces.
Bulletins: Data sheets & process designer's catalogs on drying, mtls. hndlg. & power transmission equip.
Personnel: A group of qualified engineers will be available.

Liston-Becker Plant, Springdale, Conn. Booth 836
Infrared continuous stream analyzers.

Logan Emergency Showers, Inc., Glendale, Calif. Booth C-142
D.S. 111—Emergency fire & decontamination showers.
Bulletins: File-folders with specs., installation details.
Personnel: H. H. Logan; E. H. Moe; R. Church.

Louisville Drying Machinery Co., Louisville, Ky. Booth 42-44
(See General Amer. Trans.)

Lovejoy Flexible Coupling Co., Chicago, Ill. Booth 448

Lukens Steel Co., Coatesville, Pa. Booth 66
Clad steels.

Luzerne Rubber Co., Trenton, N. J. Booth 409
Hard rubber pumps, valves, pipe & fittings.

Machlett & Son, E., New York, N. Y. Booth C-33

Magnetic Engrg. & Mfg. Co., Clifton, N. J. Booth 236
D.S. 112—Magnetic separators.
Bulletins: Individual product lit. showing design, with selection factors; power, dimen. data.
Personnel: J. Ferris, pres.; D. J. Cockrell, sales mgr.; R. Spits, asst. sales mgr.; E. Stone; F. Weiss.

Magnetrol, Inc., Chicago, Ill. Booth 431
D.S. 113—Liquid level controls operating on induction principle.
Bulletins: Illustrate principle, model variations. List info. to supply.
Personnel: L. E. Styler, sales mgr.; B. L. Binford, chf. engr.; R. Haupt.

Manton-Gaulin Mfg. Co., Everett, Mass. Booth 406
Homogenizers.

Marco Co., Inc., Saginaw, Mich. Booth 540-544
D.S. 114—Marco Flow-Master contin. reactor mixer. Other contin. process. equip. for homogenizing, etc. Sanitary rotary pumps.
Bulletins: 4-p. Flow-Master contin. reactor shows model variations vs. application. 8-p. Flow-Master pumps detailed selection guide.
Personnel: J. Marco, pres.; R. F. Sparrow, sales mgr.; W. J. Kirkpatrick; T. Leek.

Martin & Co., H. S., Evanston, Ill. Booth C-138—C-140

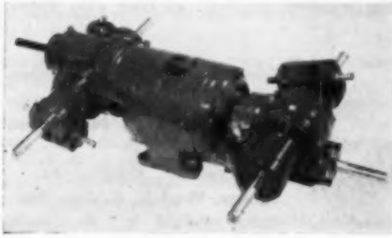
Martinson Mach. Co., Kalamazoo, Mich. Booth C-136
D.S. 115—Hercules Hi-Shear viscometer, & rotational instr. which plots torque vs. rate of shear over range of 0 to 4500 recip. seconds. Martinson laboratory coating machine for spreading liquid films.

(Continued on page 101)

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Bulletins: On above, illustrated, with appens. info.
Personnel: H. H. Norquist, mgr.

Master Electric Co., Dayton, Ohio. Booth 57
D.S. 116—Wide line of electric power drives. New Unibrake motor.



Personnel: W. R. Clements, v. p. & sales mgr.; R. L. Wolfe, mgr. application eng.; J. R. Burnett; R .T. Congleton; W. F. Grau; L. M. Richards.

Merco Centrifugal Co., San Francisco, Calif. Booth 2
D.S. 117—New Mercone continuous liquid-solids separator develops 1800 centrif. gravities. Uses a unique increasing diam. screen to dewater, filter or clarify. Also centrif. separating discs, to 24 in.
Bulletins: 4-p. centrifugal sepn. guide to five basic separations, with flow diagrams. 4-p. mersone with cross-secl. drwgs., chart; 2-p. on hydraulic hoist.
Personnel: W. Wiisanen, v. p.; H. H. Pomeroy, sales mgr.; R. Haskins; J. Nargang.

Metal Textile Corp., Roselle, N. J. Booth C-65

Metalab Equip. Corp. Hicksville, N. Y. Booth 901
D.S. 118—Laboratory furniture & equip. New highly resistant table top matl. in colors.
Bulletins: Revised 12-p. sectional unit indus. cat.; 12-p. genl. cat.; Metal-Aire fume hood.
Personnel: H. M. Plant, pres.; W. A. Reed, sales mgr.; M. C. Wilson.

Metalweld, Inc., Philadelphia, Pa. Booth 240
D.S. 119—Organic & sprayed-metal coatings & linings.
Bulletins: Individ. bulletins on each principal category of line with resistivity charts; also tech. reprint on tank cars.
Personnel: S. J. Oechsle, Jr., genl. mgr.; K. G. LeFevre, sales mgr.; H. S. Hammond; J. H. Briscoe; D. H. Reinert; Wm. R. Wright.

Mettler Instrument Corp., Hightstown, N. J. Booth 18

Mic-Lin Co., Merchantville, N. J. Booth S-71

Miller & Son, Inc., Franklin P., E. Orange, N. J. Booth C-117—S-31
D.S. 120—Size reduction equipment intended for large chunks of wax, resin, urea cake, etc. Reduces to ½ in. or less. Also dry ice crusher.
Bulletins: 2-p. heavy duty crushers, & dry ice folders, with dimens., prices, etc.
Personnel: H. Galanty, v. p. engrg.

Milton Roy Co., Philadelphia, Pa. Booth 313
D.S. 121—ΔP downhill metering (minus delta P) controlled volume pump of leakproof construc. for highly corros. or hazardous liquids. Accurately meters from higher to lower press. Also motor driven control. vol. pump with instrument air stroke length adjustment, as final control element in process systems. Other displays.
Bulletins: New lit. No. 855 & No. 955 on the two above new items.

(*Continued on page* 103)

CANDIDATES FOR MEMBERSHIP IN A. I. Ch. E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on admissions.

These names are listed in accordance with Article III, Section 8, of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members will receive careful consideration if received before December 15, 1955, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Beeck, R., *Lima, Peru*
Byorum, R. A., *Kansas City, Mo.*
Carlson, Robert A., *El Cerrito, Calif.*
Cross, Raymond B., *Philadelphia, Pa.*
Dunne, Bernard A., *Huntington Park, Calif.*
Ednie, N. A., *Wilmington, Del.*
Ewing, Frank H., Jr., *Hopewell, Va.*
Frey, Robert E., *Painesville, Ohio*
Githens, Richard E., Jr., *Wilmington, Del.*
Gonzalez, Juan R., *Santurce, Puerto Rico*
Graef, Elbridge R., *Charleston, W. Va.*
Hertweck, John F., *Port Arthur, Tex.*
Hull, Lewis W., *Abington, Pa.*
Johnson, Virgil A., *Houston, Tex.*
Kibby, Harold R., *Homewood, Ala.*
Lemieux, Elzear J., *Westbury, N. Y.*
Mares, Joseph R., *Dickinson, Tex.*
McKinney, John F., Jr., *Marcus Hook, Pa.*
Mecham, William J., *Chicago, Ill.*
Michaels, Alan S., *Lexington, Mass.*
Moriarty, Eugene, *Chicago, Ill.*
Myers, Henry S., *Brooklyn, N. Y.*
Oberg, A. G., *Lubbock, Tex.*

(*Continued on page* 104)

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Personnel: R. T. Sheen, pres.; W. T. Griffiths, v. p. sales; J. Barron, chf. engr.; J. Procopi; H. R. Smith, chf. appln. engr.

Mine Safety Appliances Co., Pittsburgh, Pa. Booth C-34
Personal protective devices.

Minerals & Chemicals Co. of America, Metuchen, N. J. Booth 807

Minneapolis-Honeywell Reg. Co., Philadelphia, Pa. Booth 531
D.S. 122—New design of Tel-O-Set miniature pneumatic instr., Honeywell Series 400 compact, med. duty diaphragm ElectroniK ¼-sec. strip chart recorder. Control valves. New Tel-O-Set press. or temp. transmitter. Honeywell data handling system.
Bulletins: A 2-p. Tel-O-Set transmitter specif. sheet. 12-p. Quick-Connect Tel-O-Set miniature instruments. 4-p. spec. sheet on diaph. control valves.
Personnel: O. B. Wilson, sales mgr.; R. Schlegel; E. J. Klein; H. Ruch; J. Root; D. Coate.

Misco Fabricators, Inc., Detroit, Mich. Booth 723
D.S. 123—Designers & fabricators of alloy process vessel equip.
Bulletins: Corrosion Guide lists approx. 300 common corrosive media with suggested resistant matls.
Personnel: G. S. Thompson, pres.; D. B. Cartwright, sales mgr.; L. Griffore, des. engr.

Mission Mfg. Co., Houston, Texas. Booth C-147
Circular-casing centrifugal pumps in metal & plastic.

Missouri Coke & Chem. Div., St. Louis, Mo. Booth 306-308
(See Great Lakes Carbon Corp.)

Mixing Equipment Co. Booth 800
D.S. 124—Exhibit will emphasize engrg., research, design & produc. services available to users of fluid mixing equipment. Working models will show flow patterns from axial & radial impellers both top- and side-entering, as well as with baffled and unbaffled tank arrangements. Models will show flow through tank center without distortion. A glass mixer-compartmented column will demonstrate gas dispersion. A full-size cut-away top-entering mixer will incorporate new mechan. seals where complete seal cartridge assembly may be removed & replaced without dismantling mixer or removing from tank.
Bulletins: Detailed, complete catalog with cutaways, specs., etc.
Personnel: J. V. Donohue, v. p. sales; R. D. Boutros, ch. engr.; J. Y. Oldshue, hd. Res. & Devel.; L. H. Mahony, Asst. S. M.; M. Dykman, Asst. Ch. Engr.

Monarch Mfg. Wks., Inc., Phila., Pa. Booth 701

Morehouse-Cowles, Inc., Los Angeles, Calif. Booth C-22
D.S. 125—Morehouse mills and Cowles dissolvers.
Personnel: G. E. Missbach, dir. & genl. sales mgr.; G. H. Morehouse, pres.; D. L. Grubbs, v. p. & genl. mgr.

Mud Products, Inc., Tulsa, Okla. Booth 824
D.S. 126—Butterfly valves sizes 1½ through 10 in. in variety of body & trim matls., ends, construc. features, etc. New models will be shown.
Bulletins: 16-p. catalog of entire line, with specs. & prices.
Personnel: H. P. Ackerman.

(*Continued on page* 105)

CANDIDATES *(Continued from page 102)*

Reichard, Harold F., *Livingston, N. J.*
Rooney, Patrick, *Oakland, Calif.*
Ruth, Ralph G., *Tulsa, Okla.*
Savage, T. A., *Garden Grove, Calif.*
Strong, E. R., *San Antonio, Tex.*
Tschopp, L. Daniel, *Houston, Tex.*
Von Stein, Manfred, *New York, N. Y.*
West, Robert F., *Caldwell, N. J.*
Wilhelm, Ernest J., *Notre Dame, Ind.*

Associate

Alert, Jerry George, *Cleveland, Ohio*
Anderson, Richard J., *Rochester, N. Y.*
Babcock, Byron D., *Wilmington, Del.*
Barlow, Jan, Jr., *Moss Point, Miss.*
Bartlett, David C., *Ponca City, Okla.*
Bashore, S. Leon, *Laureldale, Pa.*
Basile, Alfredo Ezio, *Lorain, Ohio*
Beadle, John W., *Cleveland, Ohio*
Beecher, Norman, *Concord, Mass.*
Benford, Charles L., Jr., *Youngstown, Ohio*
Berry, William L., Jr., *Cape Girardeau, Mo.*
Blanc, Fernando Etienne, *Santiago de Cuba, Cuba*
Brandstaetter, John O., *Mentor, Ohio*
Bray, John C., Jr., *Skokie, Ill.*
Brown, Allen W., *Covington, Ky.*
Brown, Jack N., *Harvey, Ill.*
Burns, Jack F., *Houston, Tex.*
Careaga, Ramiro, *Brooklyn, N. Y.*
Chapman, James W., *Sault Ste. Marie, Mich.*
Chastain, William Roy, *Barberton, Ohio*
Ching, George P. K., *Kearny, N. J.*
Chirico, D. Daniel, *Phila., Pa.*
Ciesla, Edward, *West Warwick, R. I.*
Clarke, Neil G., *Brewer, Me.*
Coignet, Alfred Louis, Jr., *Lakeland, La.*
Conti, Joseph Charles, *Buffalo, N. Y.*
Cooley, James A., *Akron, Ohio*
Cory, T. C., Jr., *East St. Louis, Ill.*
Cox, Howard A., *Worthington, Ohio*
Dellert, Richard H., *Chicago, Ill.*
Dickert, Bacil F., *Columbia, S. C.*
Doyle, William J., *St. Louis, Mo.*
Dreifus, Harry, *New York, N. Y.*
DuBois, J. B., Jr., *Houston, Tex.*
Englander, Irwin, *Brooklyn, N. Y.*
Farrah, John H., *Corpus Christi, Tex.*
Feehs, Richard H., *Phila., Pa.*
Fella, James, *La Marque, Tex.*
Feltham, James E., *Anniston, Ala.*
Fergusson, James G., *Elizabeth, N. J.*
Fleming, Carl E., *Lakewood, Ohio*
Forster, Eugene J., *Detroit, Mich.*
Frenkel, H. David, *Caracas, Venezuela*
Gadbois, George S., *Colchester, Conn.*
Garber, J. Kirk, *Lititz, Pa.*
Gary, William A., *Oak Ridge, Tenn.*
Glahn, Gerald L., *Bartlesville, Okla.*
Grazulis, Edward J., *Louisville, Ky.*
Hammond, Wendell B., Jr., *Middletown, Ohio*
Hart, F. David, *Woodbury Heights, N. J.*
Hawk, Willis R., *Terre Haute, Ind.*
Haynes, Donald J., *Cincinnati, Ohio*
Henry, Edgar N., *Sistersville, W. Va.*
Herbert, Frank H., *St. Albans, W. Va.*
Hibbert K. M., *Montreal, Que., Can.*
Hodgson, Richard E., Jr., *Los Angeles, Calif.*
Hoge, John H., *New Knoxville, Ohio*
Hollen, William H., *Lakewood, Ohio*
Holmberg, Roy L., *Burlington, Iowa*
Holve, W. A., *No. Plainfield, N. J.*
Hutchins, Clinton Eugene, *Strong, Me.*
Johnson, Douglas L., *Arsenal, Ark.*
Kava, Donald J., *Buffalo, N. Y.*
Kazmierczak, Leon J., *Linwood, Pa.*
Kealy, Joseph P., *Riverdale, Ill.*
Kesten, Arthur, *New York, N. Y.*
Kiley, R. Cynthia, *Sea Girt, N. J.*
Kilponen, Kenneth C., *Wakefield, Mich.*
Koontz, William P., *China Lake, Calif.*
Kornafel, Katherine, *Berkeley, Calif.*
Kremenik, Stephen F., *West Covina, Calif.*
Lamothe, Henry J., *Frederick, Md.*
Lu, Robert P. L., *Deepwater, N. J.*
Malloy, John P., *South Plainfield, N. J.*
Martin, Richard W., *Milton Junction, Wis.*
McCorkle, John Earl, *Somerville, N. J.*
Miller, James E., *Wilmington, Del.*
Miller, Wayne L., *Tulsa, Okla.*
Moll, Glenn L., *Columbus, Ohio*
Moreau, Eugene M., *Portland, Me.*
Morgan, James I., *Midland, Mich.*

(Continued on page 112)

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Multi Metal Wire Cloth Co., Inc., New York, N. Y. Booth 204
Wire cloth for filtration & other purposes.

Murray Tube Works, Inc., Elizabeth, N. J. Booth 5-32
D.S. 127—Line of tube, tubing & fitting products in s.s. and other metals & alloys.
Bulletins: 24-p. Bulletin listing sizes & quan. of tub. prods. available from present stock. S.S. Supplement lists same for s.s. tub. prods.
Personnel: J. Lussen, sales engr.; F. P. Morris; J. A. Roberts; W. Weber; W. Brown; J. A. Bonnel.

Naresco Equip. Corp., Newton Highlands, Mass. Booth C-115

Nash Engineering Co., So. Norwalk, Conn. Booth 400
Air compressors & vacuum pumps.

National Carbon Co., N. Y., N. Y. Booth 350
(See Union Carbide & Carbon Corp.) Karbate graphite heat exchangers, towers pipe & fittings, centrifugal pumps, etc.

National Drying Mach. Co., Philadelphia, Pa. Booth C-62

National Dust Collector Corp., Chicago, Ill. Booth 232

National Engineering Co., Chi., Ill. Booth 232
D.S. 128—Simpson Mix-Muller, a mulling type mixer for high solids—liquid ratios; also the National Hydro-Filter wet dust collector using packed tower principle.
Bulletins: 12-p. Mix-Muller & applications & selection data. 12-p. Hydro-Filter, same type details.
Personnel: E. B. Henby; R. P. Osko; W. A. Kellogg; G. T. Dupre'; C. H. Wells.

Nat'l. Filter Media Corp., New Haven, Conn. Booth 616

Nat'l. Lead Co., New York, N. Y. Booth 702-706-708
Lead valves, tubing, pipe, acid recovery plants, etc.

National Resin Oil Products, Inc., Savannah, Ga. Booth 64
D.S. 129—Rosin oils & pitches, plus Galex a non-oxidizing rosin. Easy to handle pellets consist mainly of dehydroabietic acid. Represents first effort to pelletize low melt. rosins.
Bulletins: 8-p. on Galex describes matl., properties & use data. New booklet on rosin oil.
Personnel: R. Bender; W. L. Hopkins, Jr.; E. Breznak.

National Tube Div., Pitts. Pa. Booth 518-522
(See United States Steel Corp.)

Neuman & Weaver, Inc., Fair Lawn, N. J. Booth C-160

Newark Wire Cloth Co., Newark, N. J. Booth 334

New Brunswick Scientific Co., New Brunswick, N. J. Booth 626

New England Tank & Tower Co., Everett, Mass. Booth 52
D.S. 130—New portable & tripod mounted propeller mixers shown in operation; Flo-Mix pipeline mixer in oper.; new line of heavy duty flange mounted agitator units; side drive propeller agitators.
Bulletins: 4-p. covers comp. line of mixing equip. Comprehensive engrg. cat. No. 530 avail. by mail.
Personnel: E. F. Page; J. J. Lennon; J. B. Eisnor.

(*Continued on page* 106)

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

New York Air Brake Co., New York, N. Y. Booth 333-335

New York Lab. Supply Co., New York, N. Y. Booth C-41

Niagara Blower Co., N. Y., N. Y. Booth 600

Niagara Filters Div., E. Moline, Ill. Booth 802-806
(See Amer. Machine & Metals.) Vertical Leaf type Pressure filters.

Nichols Engrg. & Res. Corp., New York, N. Y. Booth 631
Multiple hearth furnaces, kilns, roasters, etc.

Nicholson & Co., W. H., Wilkes-Barre, Pa. Booth 132
Steam traps.

Niles Steel Prod. Div., Niles, O. Booth 535-539
(See Republic Steel Corp.)

Nordstrom Valve Div., Pitts., Pa. Booth 617
(See Rockwell Mfg. Co.) Lubricated plug-type valves.

North American Philips Co., Inc., Mt. Vernon, N. Y. Booth 648
D.S. 131—Two models of electron microscopes; diffractometer; X-ray spectograph; X-ray microradiograph; liquid air machine.
Bulletins: Questions & Answers on Electron Microscopes; also X-ray Analysis.
Personnel: *C. J. Woods; T. Turnbull; J. Gasteiro; R. Miller; E. Champaygne.*

Oil & Gas Div., New York, N. Y. Booth 306-308
(See Great Lakes Carbon Corp.)

Okadee Valve Co., Chicago, Ill. Booth 824

Omega Machine Co., Providence, R. I. Booth 902
D.S. 132—A complete new line of gravimetric feeders of the loss-in-weight type, for feeding wide range of liquids & solids at rates from 1 to 60,000 lb./hr. Also shown, I-beam proportioning pumps with vane guide check valves. Also Hi-Weigh belt gravimetric feeder for dry materials at med. to high rates.
Bulletins: New literature on the first two items. 2-p. on the Hi-Weigh model.
Personnel: *R. P. Lowe, pres.; R. H. Glanville, exec. v. p.; P. A. Coffman, v. p. & chf. engr.; F. W. Deutsch, sales mgr.; A. A. Melnychuk; E. B. Lynch.*

Oronite Chemical Co., San Francisco, Calif. Booth C-23
D.S. 133—Oronite isophthalic, a new raw matl. with good props. for paint, resin & plastic fields is featured. Also on display detergents, lub. oil additives, polybutenes & surfactants.

Owens-Corning Fiberglas Corp., Toledo, Ohio. Booth 618-620
D.S. 134—Kaylo "20" high temp. insul. being introduced to chem. proc. industry. Applicable to 1,800° F. Also line of insulation prods. for temps. from absol. 0 to 2,000° F.
Personnel: *H. T. Williams, mgr. indus. construc. matls.; W. S. Haynes, mgr. engrg.; G. W. Volckhausen, asst. sales mgr.; W. E. England; W. H. Wiseman; R. J. Littin.*

Pangborn Corp., Hagerstown, Md. Booth 906
Dust collectors.

Parker Appliance Co., Cleveland, O. Booth 74
D.S. 135—Tube fittings. Also new flareless type for instrument lines of copper or nylon tubing. Features rapid, easy makeup of conn. without disassembly.

Bulletins: Cat. 12-p. selec. guide on Intru-Lok; 1-p. data sheet on Torkgrip bender.
Personnel: D. A. Cameron, genl. sales mgr.; C. E. Klamm; W. D. Wynant, sales mgr.; t. & h. div.; R. B. Jewett; H. A. Ludlam; S. E. Voran.

Parke-Cramer Co., Fitchburg, Mass. Booth 727

Patterson Fdry. & Mach. Co., E. Liverpool, O. Booth 331
D.S. 136—New design pebble & ball mill, plus Jet mill for high speed liquid dispersions, being introduced. A scale model of a complete synthesizing plant, liq. & dry blending equip. will be shown. Conaform vacuum dryer will be operating.
Bulletins: 8-p. bull. on Futura mills; 8-p. bull. on Jet mill dispersion.
Personnel: R. L. Cowood, pres.; H. M. Brown, v. p.; D. M. Wilhelm, v. p.; C. G. Kiernan; W. H. Henzey; W. J. Hood; J. E. Wright.

Patterson-Kelley Co., Inc., E. Stroudsburg, Pa. Booth 739-831
D.S. 137—New 3 cu.ft. P-K twin shell blender liquid feed—intensifier model. So modified that liquid may be introduced through the intensifier bar in fine mist form & homogeneously mixed with dry solids. New Lever-Lock quick opening door. A 15 gal. resin pilot plant.
Bulletins: Available will be 12-p. detailed cat. on blenders, heat ex., & reactors. 4-p. on P-K Lever-Lock door.
Personnel: J. K. Petry, sales mgr.; J. J. Fischer, chf. engr.; H. W. Donaghy, Jr.; D. E. Jaggard.

Peabody Engrg. Corp., N. Y., N. Y. Booth C-116
D.S. 138—A line of scrubbers, coolers, absorbers, & air heaters.
Bulletins: 6-p. on direct-fire air heaters, illus. Diagrammatic sketches & cutaway views plus pertinent data. 6-p. on scrubbers. Features, applications, sketches, included.
Personnel: E. G. Peterson, v. p.; R. S. Kopita; G. E. Smith; M. P. Ellis.

Peerless Pump Division, Los Angeles, Calif. Booth 805
D.S. 139—Chemical centrifugal pumps for corros.-resis. services. Feature max. interchangeability with low inventory requirements.
Bulletins: An interchangeability chart with bull. on individual products.
Personnel: R. P. Young; J. W. Nolan; W. B. McNew; G. C. Carnahan; P. M. Dixon; R. P. Stephens; H. R. Franz; J. R. Bateman.

Penberthy Injector Co., Detroit, Mich. Booth 426
(See Buffalo-Eclipse Corp.)

Perkin-Elmer Corp., Norwalk, Conn. Booth 705
D.S. 140—Newest item is Vapor Fractometer, gas chromatography device for anal. of gases & low-boil. liquids. Also the Tri-Non infrared process stream analyzer, & the Bichrometer a dispers. type process stream anal. Also the Auto-Zoom lens model 16TV a 5-1 focal range zoom lens for use with Vidicon tubes & 16 mm. TV cameras.
Bulletins: 6-p. of applns. data, etc. on Fractometer plus other lit.
Personnel: P. Hutchinson, sales mgr. lab. instru.; J. L. Borden sales mgr. proc. cont. instru.; V. Coates; E. Garlock; A. Savitzky; P. A. Wilks.

Perlite Div., Los Angeles, Calif. Booth 306-308
(See Great Lakes Carbon Corp.)

Permutit Co., New York, N. Y. Booth 73

Perry Products Co., Philadelphia, Pa. Booth 437
D.S. 141—Stainless steel mixing tank with component parts. Also other tanks in line & a s.s. agitator.
Bulletins: 8-p. illus., details on weld. processes, sketches of access., dimen., sizes, etc. Stock tank bull. on products avail. for prompt deliv.
Personnel: P. Epstein, pres.; J. Epstein, v. p.; A. L. Zarow; H. Goodman; R. Pisano; B. Betz.

(*Continued on page* 108)

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Petro-Chem Devel. Co., Inc., New York, N. Y. Booth C-44
Cracking furnaces.

Pfaudler Co., Rochester, N. Y. Booth 502
D.S. 142—Newly des. 500 gal. glassed steel reactor; 28 ft. high glassed steel column; first showing at an Exposition—glassed steel rotary dryer & blender & a 10 gal. reactor of titanium.
Personnel: E. W. Nelson, chem. sales mgr.; H. J. Edwards, genl. sales mgr.; S. A. Smith.

Pharm. & Chem. Industry Supply Corp., New York. Booth C-55

Phila. Gear Works, Phila., Pa. Booth 33
D.S. 143—A complete line of packaged fluid agitators for the chemical process industry.
Bulletins: Separate illus. catalogs on fluid agitators, Limitorque valve control, Sphereflex gear couplings, & a 76-p. book on gears.
Personnel: R. C, Ball, pres.; R. C. Ball, Jr., v. p.; Lee Cox.

Phila. Pump & Mach. Co., Phila. Pa. Booth C-130
D.S. 144—Pumps & proportioning equip., low, stand., & high press. to 50,000 lb./sq.in.
Bulletins: 4-p. "Packaged Chemical Feed Systems." 16-p. "Controlled Capacity Pumps," on low & stand. press. types—62 models.
Personnel: J. A. Eagan, pres.; I. T. Goodspeed, asst. to pres.; E. J. Ill.

Philadelphia & Suburban Tire Service, Yeadon, Pa. Booth S-115

Photovolt Corp., New York, N. Y. Booth 635
D.S. 145—Displayed will be a line of pH meters, photoelectric colorimeters, many other types of meters.
Bulletins: On units displayed.
Personnel: F. Lonberg, pres.; B. A. Silard, v. p.; S. E. Krewer, dir. res.; H. C. Sondergaard; G. H. Lovins; D. Friedmann.

Platecoil Div., Lansing, Mich. Booth 340-342-344
(See Tranter Mfg. Co.)

Pneumatic Scale Corp., Ltd., Quincy, Mass. Booth 77
D.S. 146—A Vacuflow powder filling mach.; automatic labelling mach., applic. to round containers at speeds to 150/min.; 2-head Air Cleaner for new glassware.
Bulletins: Tri-Mac labelling mach.; Lighning I & II units; on new line of Pneumacap capping equip.
Personnel: D. W. Tiano; O. H. Hultin; W. B. Powell; W. H. Weeden.

Podbielniak, Inc., Chicago, Ill. Booth 601
D.S. 147—Chemizon Podbielniak countercurrent centrifugal solvent extractor for processing rates up to 500 gal./min. The Thermocon said to be most accur. apparatus for analyzing lt. hydrocarbon gases.

Bulletins: Chemizon loose-leaf binder with construction details, dimensions, operation, etc. Also tech. data sheets on Thermocon.
Personnel: W. J. Podbielniak, pres.; C. M. Doyle, v.p. & genl. mgr.; H. R. Kaiser, v.p.; G. J. Ziegenhorn; S. T. Preston; A. M. Gavin.

Papper & Sons, Inc., New York, N. Y. Booth 907

Porter Co., Inc., H. K., Roselle, N. J. Booth 722

Poly-Seal Corp., New York, N. Y. Booth S-28
D.S. 148—Plastic closures for bottles—a screw cap with polyethylene liner.
Bulletins: 4-p. illus. brochure on construc.-features, uses.
Personnel: J. A. Elder, Jr., chf. engr.; D. N. Robineau; J. Banfield; L. Miller.

Potter Aeronautical Co., Union, N. J. Booth C-40
D.S. 149—Extended range (to 30,000 to 1) mass flowmeter having accuracy of ±½% of full scale; line of flow controllers. Also density meter and new low range flow meter (from 0.07 gal./min.)
Bulletins: 2-p. specs. sheet on new computing counter used with Potter flow sensing element; 4-p. specs. sheet data & characteristics of all flow sensing elements.
Personnel: D. M. Potter, owner; I. Hirsch, genl. mgr.; R. Schooley; J. Meyer; A. Toth; H. Whittle; C. Faust; G. Fitzpatrick.

Potts Co., Horace T., Phila., Pa. Booth 307
D.S. 150—Welding fittings of s.s., Exclus. tangential feature said to aid alignment. Special insert flange elim. welding.
Bulletins: Catalog—24-p. detailed selection guide.
Personnel: J. W. Reckard, genl. sales mgr.; R. P. Curtin; T. L. Andrew; W. H. Van Horn; W. H. Dunlap; W. W. Morris.

Powell Co., The Wm., Cincinnati, O. Booth 48
Valves of corrosion-resistant material.

Prater Pulverizer Co., Chi., Ill. Booth 336-338
D.S. 151—Complete line of rotary airlock feeders with new cutaway sect. of 12 in. feeder. Models PAV-8J & PAV-10J are blow-thru types, integral with pipeline in pneu. convey. system.
Bulletins: New booklet covers details of full line & applications.
Personnel: G. F. Thomas, pres.; P. E. McKamy; J. Kotilinek.

Precision Scientific Co., Chicago, Ill. Booth 67
D.S. 152—Will show 300 color transparencies of laboratory analytical products manufactured.
Bulletins: 2-p. midget water stills. 4-p. dual titrometer. Also lit. on flash point testers, auto. titrating & pH record. instruments, distill. apparatus.
Personnel: J. J. Kinsella, pres.; E. M. Becker; A. Stratton; R. S. Karas; J. Black.

Precision Thermom. & Instru. Co., Philadelphia, Pa. Booth S-66

Premier Mill Corp., Geneva, N. Y. Booth 309
Colloid mills.

Pressed Steel Tank Co., Milwaukee, Wis. Booth 714
Containers of metal & alloy construction.

Pressure Products Industries, Inc., Hatboro, Pa. Booth C-37
D.S. 153—High pressure valves & fittings, pumps, magnetic-agitated vessel, 10 gal. size. Also canned motor drive with Gaspersator turbine agitator, a 5,000 lb./sq.in. reactor with rotary stirrer rupture assemblies.
Personnel: R. C. Wolf, pres.; J. C. Bowen, v.p.; J. G. Leaming; W. N. Drain, Jr.

Proctor & Schwartz, Inc., Phila., Pa. Booth 950
Dryers.

(*Continued on page* 110)

DECEMBER, 1955

A. I. Ch. E. JOURNAL

Published by the American Institute of Chemical Engineers

PURPOSE

The rapid development and expansion of chemical engineering has necessitated a separate publication covering basic research in the field.

The AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, recognizing its responsibility to the profession, has inaugurated a quarterly to be devoted to the science of chemical engineering.

The new technical journal is required reading for research, design, and development engineers in every phase of chemical engineering.

Subscription: Members, $4.50 annually, $7.50 for two years; Nonmembers, $9.00 annually, $16.00 for two years.

A.I.Ch.E. JOURNAL
25 West 45 Street
New York 36, New York

Enclosed is my check ___ money order ___ for $............ for a ___ one-year, ___ two-year subscription to the A.I.Ch.E. Journal.

Name..

Address..

....

Member ☐ Associate member ☐ Affiliate ☐ Student ☐ Nonmember ☐

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Productive Equip. Corp., Chicago, Ill. Booth 207
D.S. 154—Vibrating screens. New low cost model being introduced.
Bulletins: No. 555 on Selectro. Kelly screen bulletin.
Personnel: L. H. Lehman, sales mgr.; R. W. Smith, asst. sales mgr.; C. B. Smith.

Proportioneers, Inc., Providence, R. I. Booth 902
D.S. 156—New proportioning pumps of simpler, more efficient design equipped with Vane-Guide check valves with reversible seat for added service life.
(Also see B-I-F Industries.)

Protective Coatings Div., Phila., Pa. Booth 240
(See Metalweld, Inc.)

Protectoseal Co., Chicago, Ill. Booth C-38
D.S. 155—Shop and lab safety storage & handling equipment for flammable solvents.

Bulletins: 2-p. Equipment Selection Guide chart classifies over 30 safety devices by application. 40-p. "Venting Fundamentals with Protectoseal Equipment."
Personnel: W. E. Belt, sales mgr.; J. T. McCarty.

Pulva Corp., Perth Amboy, N. J., Booth 330
D.S. 157—Display includes model B Pulva-sizer a screwfeed mill using hammers, a Com-Bin feeder for non-free flowing materials. Pulvalves.
Bulletins: Condensed cat. on Pulva-Sizer line. Bull. describing Com-Bin feeder. Revised genl. cat.
Personnel: F. Kolisek, secy. & treas.; W. W. McNamara; R. Brelle & sales representatives.

Pulverizing Mach. Division, Summit, N. J. Booth C-30
D.S. 158—Pulverizers—with new 50 h.p. Mikro-Bud for handling intermed. fine grinds in large capacities. Also new Mikro-Multi D for particle control in the 4 to 20 mesh range.
Bulletins: Mikro genl. catalog; bulletins on Mikro-Bud and Multi-D.
Personnel: E. L. Timm, sales mgr.; N. Hoff; W. Sheldon; H. Mercready; A. L. Stern; T. Reinauer.

Quaker Oats Co., Chicago, Ill. Booth 65
D.S. 159—Furan chemicals including furfural, furfuryl alcohol, levulinic acid, other chemicals.
Bulletins: Literature on chemistry & uses of items mentioned will be available. Several available at booth.
Personnel: E. A. Reineck; J. R. King; J. J. Howe; D. J. Spence; R. W. Reardon; R. H. Wittekindt.

Quelcor, Inc., Chester, Pa. Booth 348
D.S. 160—PVC plastisols; laminated PVC & rigid sheets; PVC blocks, gaskets & molded items & elec. welding guns.
Bulletins: 8 Data sheets.
Personnel: J. W. Pedlow, pres.; R. Golong, v.p.; W. Johnson; J. Roberts, sales mgr.; L. Shears; W. Locke.

RKL Valve & Mfg. Co., Philadelphia, Pa. Booth S-71

Raybestos-Manhattan, Inc., Manheim, Pa. Booth 218

Raymond Div., Chicago, Ill. Booth 68
(See Combustion Engr., Inc.)

Read Standard Corp., York, Pa. Booth 608
Kneading and ribbon type mixers, pos. displacement blowers, weigh-hoppers, conveyors.

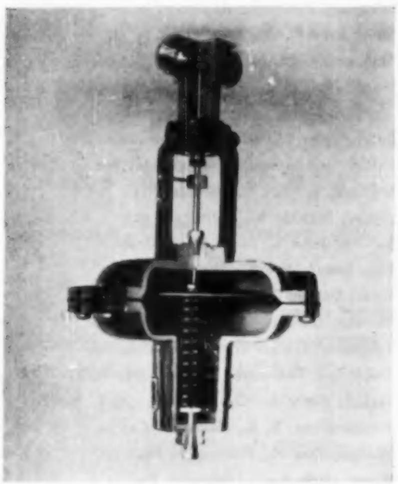
Reeves Pulley Co., Columbus, Ind. Booth C-165, C-167

Rem-Cru Titanium Inc., Midland, Pa. Booth 433
Titanium in various forms.

Republic Lead Equipment Co., Cleveland, Ohio. Booth 10-12-14
Lead lined process equipment.

Republic Steel Corp., Cleveland, Ohio. Booth 535-539
D.S. 161—The Steel & Tubes Div. will show new Farrowtest nondestructive electronic test for defects in carbon or s.s. tubing & pipe. Also a display of Enduro s.s. & other Republic products.
Bulletins: 4-p. on Farrowtest unit & its operation, 12-p. on electrunite C-steel heat exchanger tubing, 12-p. on Enduro s.s. ht. exch. tubing.
Personnel: W. J. Resiner; E. H. Wardle; C. J. Boyd; J. H. Fishel; B. J. Keffler; S. A. Seckler; T. E. Perry; R. E. Rowland; R. Geiser; S. P. Odar.

Research Controls, Tulsa, Okla. Booth C-134
D.S. 162—Miniature flow control equip., principally automatic diaphragm oper. flow valves normally 1/8 in., 1/4 in., & 1/2 in. IPT.



Bulletins: 4-p. selection guide on members of line, plus 3-p. of nomographs on steam, air & liquids flow.
Personnel: R. Horton, partner; P. M. Sanders; W. A. Diamant; W. Addy; W. E. Thomas; W. B. Farley; R. K. Leinhart; J. Palme; G. Kauer, Jr.

Resistoflex Corp., Belleville, N. J. Booth 248
D.S. 163—Flexible hose & laminated pipe & fittings; molded bellows, diaphragms & beakers.
Bulletins: 4-p. selec. guide on Fluoroflex Teflon & Kel-F hose & assemblies; 4-p. on Fluoroflex laminated pipe & assemblies; other 4-p. & data sheet units.
Personnel: H. H. Wulff; T. R. Thierry; B. M. Walker; H. E. Krebs, sr. v. p. & sales mgr.; A. N. T. St. John, v.p. planning & devel.

(*Continued on page* 112)

C. E. P.

Monograph

1. **Reaction Kinetics by Olaf A. Hougen**
(74 pages; $2.25 to members, $3.00 to nonmembers)
2. **Atomization and Spray Drying by W. R. Marshall, Jr.**
(122 pages; $3.25 to members, $4.25 to nonmembers)

and Symposium Series

1. **Ultrasonics—two symposia**
(87 pages; $2.00 to members; $2.75 to nonmembers)
2. **Phase-Equilibria — Pittsburgh and Houston**
(138 pages; $3.75 to members, $4.75 to nonmembers)
3. **Phase-Equilibria—Minneapolis and Columbus**
(122 pages; $3.75 to members, $4.75 to nonmembers)
4. **Reaction Kinetics and Transfer Processes**
(125 pages; $3.75 to members, $4.75 to nonmembers)
5. **Heat Transfer—Atlantic City**
(162 pages; $3.25 to members, $4.25 to nonmembers)
6. **Phase-Equilibria — Collected Research Papers for 1953**
(113 pages; $3.25 to members, $4.25 to nonmembers)
7. **Applied Thermodynamics**
(163 pages; $3.25 to members, $4.25 to nonmembers)
8. **Communications**
(57 pages; $1.00 to members, $1.50 to nonmembers)
9. **Heat Transfer — Research Studies for 1954**
(67 pages; $1.50 to members, $2.25 to nonmembers)
10. **Collected Research Papers—for Spring 1954**
(142 pages; $3.25 to members, $4.25 to nonmembers)
11. **Nuclear Engineering—Part I**
(280 pages; $3.25 to members, $4.25 to nonmembers)
12. **Nuclear Engineering—Part II**
(259 pages; $3.25 to members, $4.25 to nonmembers)
13. **Nuclear Engineering—Part III**
(274 pages; $3.25 to members, $4.25 to nonmembers)
14. **Ion Exchange**
(121 pages; $3.25 to members, $4.25 to nonmembers)
15. **Mineral Engineering Techniques**
(96 pages; $2.50 to members, $3.75 to nonmembers)
16. **Mass Transfer—Transport Properties**
(125 pages; $3.25 to members, $4.25 to nonmembers)
17. **Heat Transfer—St. Louis**
(109 pages; $3.25 to members, $4.25 to nonmembers)

American Institute of Chemical Engineers
25 West 45 Street, New York 36, New York

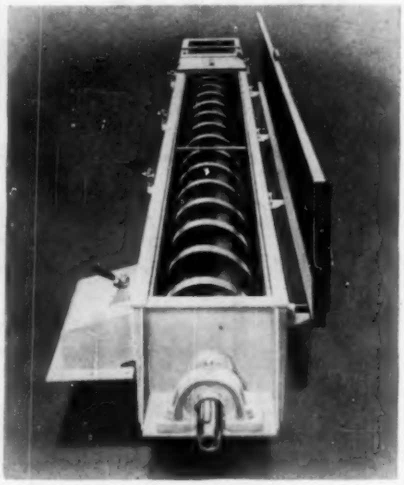
25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Reynolds Metals Co., Richmond, Va. Booth 436
D.S. 164—Aluminum chems. include calcine, trihydrate, activated. Aluminum tubing, tread plates, etc. Line of shipping containers for liqs. & solids.
Bulletins: Chem. data pages: R-2003 calcine alumina; R-2101 & 2102—activated alumina; R-5002 & 5003 organic free alumina trihydrate.
Personnel: L. V. Sheain; L. S. Beeler; J. F. Martin; R. Dalrymple; C. R. Schall; W. B. Moore.

Rheem Mfg. Co., Chicago, Ill. Booth 621-625

Richmond Mfg. Co., Lockport, N. Y. Booth 6

Rietz Manufacturing Co., Santa Rosa, Calif. Booth 719, 721
D.S. 165—A new inverted model disintegrator for contin. mixing & dispersion of liquids, slurries & powders; Thermascrew hollow screw ht. exch. for con. htg. or cooling; an angle disintegrator in lab size.



Bulletins: Two 4-p. illus. bull. & data sheets.
Personnel: P. H. Mulcahy, v. p.; A. B. Dunwoody, v. p.; R. B. Dunwoody; M. Hobson.

Robbins & Meyers, Inc., Springfield, O. Booth 32
D.S. 166—Working as well as cutaway models of Moyno pumps.
Personnel: F. H. Grim, sales mgr.; R. H. Colbert, asst. sales mgr.; R. H. Kerrigan; G. H. Zimmer; J. D. Bourke; J. J. Burke.

Rochester Mfg. Co., Inc., Rochester, N. Y. Booth 422

Rockwell Mfg. Co., Pittsburgh, Pa. Booth 617

Ross & Son Co., Inc., Chas., Brooklyn, N. Y. Booth 447
D.S. 167—Change can mixers of 60 & 80 gal. sizes; 150 gal. double-arm kneader; 9 x 24 in. high speed 3-roller mill. Mixers with double planetary stirrer action in sizes from 1 gal. for the lab. to 150 gal.
Bulletins: 32-p. data file folder.
Personnel: L. K. Ross, v. p. & treas.; C. K. Ross, asst. to pres.; J. G. Teleky; C. H. Hill; C. F. Hill; W. C. Calihan.

Roth Co., Roy E., Rock Island, Ill. Booth S-37

Rotherm Engineering Co., Chi., Ill. Booth C-143
D.S. 168—Revolving joints for air, steam &

(*Continued on page* 113)

CANDIDATES

(*Continued from page 104*)

Morrison, Grant C., *Floral Park, N. Y.*
Muzzy, Conrad, *Pensacola, Fla.*
Olin, Joe H., *Memphis, Tenn.*
Olive, J. H., Jr., *Texas City, Tex.*
O'Meara, Arthur L., *Louisville, Ky.*
Orr, Allen R., *Big Spring, Tex.*
Palmer, Philip M., *Lansing, Mich.*
Parrone, John J., *Lynchburg, Va.*
Paskind, Jack, *Evans City, Pa.*
Pilaro, Joseph F., *Lynbrook, N. Y.*
Pratt, Loren M., *Portland, Ore.*
Rannie, Robert P., *Independence, Mo.*
Redfield, John A., *Cincinnati, Ohio*
Reed, Warren A., *Elyria, Ohio*
Reedy, Joe Paul, *Bluff City, Tenn.*
Reeves, John L., *Dallas, Tex.*
Reid, J. H., Jr., *Atlanta, Ga.*
Rianhard, Lockwood, Jr., *Rome, N. Y.*
Rivenbark, Thomas A., *Mentor, Ohio*
Robertson, Jerry L., *Vinita, Okla.*
Rogers, Charles J., Jr., *Cayce, S. C.*
Rollwage, W. A., *Lake Jackson, Tex.*
Roof, Marvin D., *Baton Rouge, La.*
Rothfield, Leonard B., *New York, N. Y.*
Roy, Paul H., *Wilmington, Del.*
Rubin, Jacob Nathan, *Auburn, Me.*
Sadowski, George S., Sr., *Oak Ridge, Tenn.*
Sakiadis, Byron C., *Wilmington, Del.*
Samples, Randall H., *So. Charleston, W. Va.*
Schoppet, Edwin F., *Ardsley, Pa.*
Shea, John F., Jr., *Snyder, N. Y.*
Shinagel, Fred, *New York, N. Y.*
Singh, Narinder Mohan, *London, England*
Sleeper, Frank Eugene, III, *Sabattus, Me.*
Smith, John W., *Memphis, Tenn.*
Snider, L. Thomas, Jr., *Pasadena, Tex.*
Stafford, William F., *Oswego, S. C.*
Stynes, Stanley K., *Detroit, Mich.*
Swartz, John E., *Terre Haute, Ind.*
Tao, James, *Seattle, Wash.*
Teter, Donald L., *Baytown, Tex.*
Thomas, Charles W., *Cincinnati, Ohio*
Tompkins, Joseph R., *Philadelphia, Pa.*
Trushin, J. Theodore, *Dobbs Ferry, N. Y.*
Turkot, Victor A., *Oreland, Pa.*
Viswanathan, V. K., *Colombo, Ceylon*
Walker, Dee H., *Pittsburgh, Pa.*
Wang, Shih Jien, *Allentown, Pa.*
Warden, Maxwell R., Jr., *Martinsville, Va.*
Warzel, Lawrence A., *Bartlesville, Okla.*
Weaver, Keith R., *Ashtabula, Ohio*
Whitmarsh, Charles L., Jr., *Louisville, Ky.*
Wiseman, Morris, *Philadelphia, Pa.*
Wutkiewicz, Conrad Donald, *Detroit, Mich.*

Affiliate

Abere, Joseph F., *St. Paul, Minn.*
Kopisch, L. C., *East Alton, Ill.*
Nickles, W. P., *So. Charleston, W. Va.*
Sadtler, Philip, *Philadelphia, Pa.*

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

hydraulic applications. Also liq. lev. controls, & air & hydraulically oper. cylinders & other mech. devices.
Personnel: H. S. Kuhn, pres.; J. N. Kelleher.

Rubicon Co., Philadelphia, Pa. Booth 745

Sadtler & Son, Inc., Phila., Pa. Booth C-144

Safety Car Htg. & Ltg. Co., Inc., New Haven, Conn. Booth 703
D.S. 169—Entoleter Impact Mill with new rotor & liner of abrasion-proof ceramic material at impact points.
Bulletins: 4-p. on Entoleter Impact Mill & Centrifugal mixer; 4-p. on High Speed Mixing.
Personnel: R. B. Dodds, v. p. & sales mgr.; R. J. Hoskins, asst. sales mgr.; G. B. Stearns; L. L. Purdy; P. Whetstone.

Saran Lined Pipe Co., Ferndale, Mich. Booth 343
D.S. 170—Pipe, fittings & valves fabricated from Saran or Saran lined. Also Saran lined centrif. pumps & new air motor oper. diaphragm valves. Wood stave pipe & wood-lined steel pipe & fittings. Corr.-resis. coatings—Neoprene new to line, plus Pliogard & Sarancote.
Bulletins: Cat. 33-p. on pipe fittings, sheets, rods, etc., of Saran. Tech. data sheet on Neoprene coatings.
Personnel: S. H. Blackmore, sales mgr.; J. A. Kloustin; J. R. Craig; R. W. McKee.

Sarco Co., Inc., New York, N. Y. Booth C-128
Steam traps.

Sauereisen Cements Co., Pitts., Pa. Booth S-26

Schneible Co., C. B., Detroit, Mich. Booth 900
D.S. 171—Schneible Multi-Wash collectors which employ air flow to impact scrubbing action to water.
Bulletins: Three case histories of actual install. in chem. field with photos.
Personnel: H. E. Gravlin, v. p. & genl. mgr.; R. G. Whitehead, asst. sales mgr.; eight mfrs. reps.

Schutte and Koerting Co., Bucks County, Pa. Booth 332

Schutz-O'Neill Co., Minneapolis, Minn. Booth 418
Pulverizing mills.

Scientific Devel. Co., State Col., Pa. Booth 713

Scientific Glass Apparatus Co., Inc., Bloomsfield, N. J. Booth 54
D.S. 172—Laboratory equipment.
Bulletins: 410-p. Inter-Joint glassware cat. plus brochures on all items displayed.
Personnel: J. Wallace, sales mgr.; J. Miller; F. Gromann; E. Borchers; R. Oelschlaeger; R. Marshall.

Scott Aviation Corp., Lancaster, N. Y. Booth C-159
D.S. 173—Inhalators & accessories.
Bulletins: Data sheets on the Hydro-Pak—No. 836 & No. 552-B the Inhalator sheet.
Personnel: L. E. Jordan, sales mgr.; W. Eckman; R. Brewer.

Sealol Corp., Providence, R. I. Booth S-25
D.S. 174—Sealol-Flexibox mech. seal featuring resilient torque spring drive, proportionate pressure Teflon ring arrangement. Seal intended for use with fluids prohibiting use of syn. rubber components. For ranges above temperature limit of Teflon, an all-metal unit assembly seal is available & will be shown.
Bulletins: 12-p. Sealol-Flexibox seals, a detailed selec. guide. 2-p. data sheet on high temp.

(*Continued on page* 114)

DATA GUIDE TO THE 25TH CHEMICAL EXPOSITION

Seal, for press. to 300 lb./sq.in., temps. 800° F.
Personnel: F. Bottomley, sales mgr.; R. D. Durrett, asst. sales mgr.; H. F. Greiner; M. H. Joyce, Jr.; W. Dutton.

Simplicity Eng'g. See Col. 2.

Selas Corp. of America, Phila., Pa. Booth 62
Gas fired heating units.

Sel-Rex Precious Metals, Inc., Belleville, N. J. Booth 107

Sharples Corp., Philadelphia, Pa. Booth C-29
Centrifugal equipment.

Sheldon Equip. Co., Muskegon, Mich. Booth C-64
Laboratory furniture.

Shriver & Co., Inc., Harrison, N. J. Booth 418
Filters.

Sier-Bath Gear & Pump Co., North Bergen, N. J. Booth 55

Simplicity Engineering Co., Durand, Mich. Booth 822
D.S. 175—Mechanical vibrating screens, feeders & conveyors & sizing.
Bulletins: No. 3255 on Simplicity 32 series pan type vibrating conveyors. Includes layout data & uses.
Personnel: R. C. Johnson, sales mgr.; A. Darcus; J. L. Patterson; R. L. Henson.

Simpson Mix-Muller Div., Chi., Ill. Booth 232
(See National Engrg. Co.)

Sly Mfg. Co., W. W., Cleveland, O. Booth 43
D.S. 176—The new item on display the Hydraclone is a wet collector. Also lab. oven, dust collector & an economy filter.
Personnel: C. Sare, pres.; D. Neustadt, genl. sales mgr.; W. Kurtz, asst. to pres.; A. Smith; W. Horr; J. Starkey.

Snyder Tool & Engrg. Co., Detroit, Mich. Booth 301

Southwestern Engrg. Co., Los Angeles, Calif. Booth C-56, C-58
Custom fabricated vessel equip., vibrating screen separators.

Sparkler Mfg. Co., Mundelein, Ill. Booth C-54
Leaf-type pressure filters.

Speedline S.S. Fittings Div., Philadelphia, Pa. Booth 307
(See Horace T. Potts, Co.)

Sperry & Co., D. R., Batavia, Ill. Booth 632
Filter presses.

Spraying Systems Co., Bellwood, Ill. Booth 833

Sprout Waldron & Co., Muncy, Pa. Booth 109-111-113
Bulk solids mat'ls. handling, size reduction, pelleting, mixing and classifying equipment.

Standard Steel Corp., Los Angeles, Cal. Booth 801

Star Tank & Fiber Corp., New York, N. Y. Booth 129

Steel & Tubes Div., Cleveland, O. Booth 535-539
(See Republic Steel Corp.)

Stoffel Seals Corp., Tuckahoe, N. Y. Booth S-73

Stokes Machine Co., F. J., Phila., Pa. Booth 910
Vacuum processing equip. & acces.; drum dryers & flakers.

Strahman Valves, Inc., N. Y., N. Y. Booth C-24
D.S. 177—Displaying a line of ram type drain valves, liq. lev. gauges, seatless piston valves, & auto. water spray nozzles.
All are illus. & give features, uses, other details.
Personnel: R. D. Jaegle, genl. mgr.; D. Strahman, sales mgr.; H. Strahman.

Sturtevant Mill Co., Boston, Mass. Booth 905
D.S. 178—Micronizer grinding, fluid jet grinding mill handles both metallic & non-metallic feed, reducing to micron sizes in capac. from ½ to 300 lb./hr., & a lab. jaw crusher & crushing rolls will be shown.
Personnel: G. P. Towle, exec. v. p.; A. T. Glynn; D. J. Sullivan; G. J. Traendly.

Superior Electric Co., Bristol, Conn. Booth C-13

Superior Tube Co., Morristown, Pa. Booth 346

Surface Combustion Corp., Toledo, Ohio. Booth 54

Swenson Evaporator Co., Harvey, Ill. Booth 932
(See Whiting Corp.)
Evaporators.

Taller & Cooper, Inc., Brooklyn, N. Y. Booth 206
D.S. 179—Gas analyzer—meas. gases & vapors in p.p.m. Telemetering system for auto. control of process functions. The Sara-Sequential auto. data record. & annunciator—to 700 con. functions. Written log of abnormal occurrences & return to normal.
Bulletins: Brochures on the following: Super Sensitive analyzer; carbon monoxide analyzer; telemetering system; Sara.
Personnel: S. Kroll, v. p.; B. J. Jacobson, sales dir.; M. M. Platz; M. Kronengold; J. Justin; S. A. Radler.

Tank Storage Div., Chicago, Ill. Booth 42-44
(See General Amer. Trans. Corp.)

Taylor Instrument Cos., Rochester, N. Y. Booth 36
D.S. 180a—Transet scanning & logging control system, plug-in indicators, recorders, controllers; Transaire temp., press. & flow, & potentiometer transmitters. Fulscope control system.
Bulletins: Transet potentiometer transmitter & the scanning & logging control system bulletin.
Personnel: A. J. Fleig, indus. sales mgr.; G. E. Howard; F. Beck; W. I. Caldwell, res. dir.; C. A. Ritter; P. Gilman.

Technicon Co., Chauncey, N. Y. Booth C-32

Terriss Div., New York, N. Y. Booth 244
(See Consolidated Siphon Supply Co.)

Thermo-Panel Div., Brooklyn, N. Y. Booth 744
(See Dean Prod.)

Thermo-Elec. Co., Inc., Rochelle Pk., N. J. Booth C-156, C-158
D.S. 180b—Display includes hi-temperature resistance bath, indicating controller & portable pyrometer.
Personnel: F. S. Walter, pres.; J. H. Collins, sales mgr.; J. J. Ghiglia; D. M. Nielsen; H. Olden; A. C. Arobone.

Thermon Mfg. Co., Houston, Texas. Booth S-34

Thomas Co., Arthur H., Phila., Pa. Booth 16

Thomas Flexible Coupling Co., Warren, Pa. Booth 225

Thropp Sons, Wm. R., Lyndhurst, N. J. Booth C-43
(See J. M. Lehmann Co.)

Titanium Alloy Mfg. Div. N. Y., N. Y. Booth 708
(See Nat'l. Lead Co.)

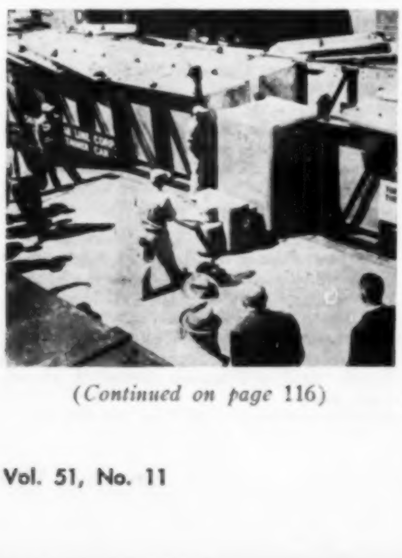
Toledo Porc. Enamel Prods. Co., Toledo, Ohio. Booth 824
D.S. 180c—V-Corr industrial roofing & siding.
Bulletins: A.I.A. File No. 12-C-1 describes V-Corr said to be strongest sheet metal known. Supplies engineering data, illus. installations, charts on methods of fastening, other data.
Personnel: H. P. Ackerman, mfrs. rep.

Toledo Scale Co., Toledo, Ohio. Booth 750

Tolhurst Centrifugals Div., E. Moline, Ill. Booth 802-806
D.S. 181—A new Tolhurst bottom unload. center-slung centrif. extractor the Maxi-Flex contin. extractor. Also new are the Niagara horizon. plate filter & Niagara H filter with scavenger.
Bulletins: General catalog.
Personnel: R. M. Hammes, genl. sales mgr.; W. C. Smith; R. T. Grimm; R. Laugel; T. M. Broughton; J. J. McHugh.

Torsion Balance Co., Clifton, N. J. Booth 847
D.S. 182—Christian Becker anal. balances, etc.
Personnel: C. T. Kasline, sales mgr.; C. H. Emberg; D. J. Farrell; J. P. Slane; H. Gebhardt.

Tote System, Inc., Beatrice, Nebr. Booth 605
D.S. 183—Tote bins & tilt dis. mechanisms for bulk inter-plant shipments or handling prob-



(Continued on page 116)

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

lems. New container car permitting bulk rail shipments in Tote bins without freight cost on bin when loaded or being deadheaded.
Bulletins: Tote cat. No. 3 & new booklet describing devel. in bulk handling.
Personnel: F. J. White, Jr.; E. A. Pagels; C. D. Ackerman; V. B. Janson.

Tranter Mfg. Inc., Lansing, Mich. Booth 340-342-344
D.S. 184—Comp. line of Platecoils—flat ht. tfr. units.
Bulletins: IP-251, genl. descrip. of Platecoils; No. 154 applications; tech. data manual for calc. ht. tfr. require. PC-55 a price list.
Personnel: J. R. Tranter, pres.; S. J. Stowell, sales mgr.; C. P. Yoder, asst. sales mgr.; C. W. Loree; R. S. Rowland; Mrs. L. S. Worthington.

Treadwell Const. Co., Midland, Pa. Booth 729

Treen Box Co., Philadelphia, Pa. Booth S-72

Trent Inc., Philadelphia, Pa. Booth 803

Tri-Clover Div., Kenosha, Wis. Booth 26
(See Ladish Co.)

Tri-Homo Corp., Salem, Mass. Booth 305
D.S. 185—A dispenser & homogenizer available in 10 sizes & types. Fab. from s.s. with chem. cer. parts ½ to 50 h.p. sizes. Three new models allow back press. in unit.

Bulletins: Cat. 20-p. in 3 colors des. comp. line of colloid mills, homogenizers & emulsifying machines.
Personnel: T. A. Sullivan pres. & treas.; P. Tognacci; A. Busteed.

Troy Engine & Machine Co., Troy, Pa. Booth 547

Truscon Steel Co., Youngstown, Ohio. Booth 535-539

Tube Turns, Inc., Louisville, Ky. Booth 49
D.S. 186—Tube-Turn welding fittings & flanges.
Bulletins: Some old & some new lit. available at booth & will cover products manufac.
Personnel: J. D. Tolliver mgr. sales devel.; J. E. Chumbley, Jr., asst. genl. sales mgr.; W. E. Geiser; S. M. Hardison; W. C. Robinson; J. D. Karthman.

Tube Turns Plastics, Inc., Louisville, Ky. Booth 47
D.S. 187—Inject. molded unplasticized PVC pipe fittings & flanges. Also PVC instrumentation tubing fittings & custom moldings.
Bulletins: A genl. folder on PVC pipe & fittings, an instrumentation fittings leaflet, folders on custom molding & solvent cement, & a corr.-resis. chart.

Laminated Dip Pipe Assembly. *Resistoflex Corp.* See D.S. 163, p. 111.

Personnel: C. B. McLaughlin, exec. v. p.; E. Erich; K. P. Chamberlain; G. Fernald.

Turbo-Mixer Div., New York, N. Y. Booth 42-44
(See Genl. American Trans. Corp.)

Turner & Haws Engineering Co., Inc. W. Roxbury, Mass. Booth 121 & 125

Tyler Co., W. S., Cleveland, Ohio. Booth 46

Uehling Instrument Co., Paterson, N. J. Booth 217
D.S. 188—A line of vac., press. vac. & press. indicators, U-tubes, inclined manometers, liq. lev. indicators, draft gauges, other control instru.
Bulletins: No. 945 on the Tank-O-Meter; No. 1146 on inclined draft gauges; No. 828 on U-tubes; No. 147 on press. & vac. gauges; No. 247 on mer. col. indicators; No. 553 on the Tel-Flo meter; Nos. 118 & 118E on Co_2 recorder. Also others on other units.
Personnel: P. J. Riccobene, sales mgr.; A. M. Foth; R. A. Kithcart.

Union Carbide & Carbon Corp., New York, N. Y. Booth 350

Union Drawn Steel Div., Cleveland, Ohio. Booth 535-539
(See Republic Steel Corp.)

Union Steel Corp., Union, N. J. Booth 440
D.S. 189—S.S. Pipe & tube. First mill to standardize on low carbon field welds. May now be made without selective corrosion in weld area due to carbide precip. without increase in cost.
Bulletins: Descrip. of new prod. in 4-p. bulletin.
Personnel: A. Leeber, pres.; J. Deitrich, v. p.; R. Cooper, v. p.; G. Hamberger; V. Segond.

Union Process Co., Akron, Ohio. Booth C-150

United Box & Lumber Co., Newark, N. J. Booth S-106

U. S. Electrical Motors, Inc., Los Angeles, Calif. Booth 148

United States Gasket Co., Camden, N. J. Booth 740

U. S. Steel Corp., Pittsburgh, Pa. Booth 518-522

U. S. Stoneware Co., New York, N. Y. Booth 10-12-14
D.S. 190—In addition to chem. ceramics, protect. coatings & linings, & spec. grind. & mix. equip., there will be a display of new Tygon ATD hot spray coatings, Tygothene gasketing, 2 new mixing devices, & a new "do-it-yourself" protec. lining.
Bulletins: 20-p. "The Story of Chemical Ceramics," 12-p. "Chemical Ceramic Vacuum Filters." 16-p. "Tygon Protective Coatings." 8-p. "Chemical Ceramic Storage Vessels." 16-p. "Intalox Saddle Packing." 20-p. "Chemical Ceramic Laboratory Sinks."
Personnel: J. M. W. Chamberlain, pres.; H. Farkas, v. p.; D. F. Siddall, dir. res.; J. Eckert; M. Leva; J. Lucas.

Van Nostrand Co., Inc., V., New York, N. Y. Booth 435

Vanton Pump & Equip. Corp., Hillside, N. J. Booth 602
(See Cooper Alloy Corp.)

Velan Engineering Ltd., Montreal, Canada. Booth 209

Victor Chemical Works, Chicago, Ill. Booth 650

Vogt. Mach. Co., Henry, Louisville, Ky. Booth 56

Votator Div., Girdler Co., Louisville, Ky. Booth 45
D.S. 191—Equip. for prod. of polyurethane & polyvinyl foams.
Personnel: J. E. Slaughter, Jr., v. p.; L. D. Roy, Jr., sales mgr.; B. D. Miller; J. Lird; H. Huber; E. T. Beck.

Walker-Wallace Div., A.P.V. Co., Inc., Buffalo, N. Y. Booth 543
D.S. 192a—Several models of APV Paraflow plate type heat exchangers.
Bulletins: 8-p. describ. constr., oper. & appli. of the APV Paraflow Unit.
Personnel: G. M. Irving, sales mgr.; J. B. Shanahan; R. K. Walz; G. F. Wachsmuth.

Wall Colmonoy Corp., Detroit, Mich. Booth 339
D.S. 192b—New liquid which controls brazing alloy surface flow & is applic. to most metals; new low-hydrogen hard-facing alloy provides low-cost impact & abras.-resis. surface; Nicrobraz s.s. braz. alloy which is now avail.; a new paste form of Nicrobraz s.s. bra. alloy.
Bulletins: Lit. on all products, including cat. on Nicrobraz—WC-63.
Personnel: L. V. LaRou, v.p. & chf. engr.; E. J. Lell, v. p. sales; W. P. Clark, v. p.; J. Kozelski; M. R. Levers, v. p.; W. R. J. Dungan, v. p.; F. T. Campo, v. p.

Wall-Derkiss, Inc., Linden, N. J. Booth 339

Wall Gases, Inc., Morrisville, Pa. Booth 339

Wallace & Tiernan, Inc., Belleville, N. J. Booth 6
D.S. 193a—There will be a Massometer in oper., plus a wall mounted chlorinator for the indus. field; a Merchen scale feeder & precis. pressure sensitive instruments.
Personnel: C. A. Rowe, asst. mgr. sales; R. C. Hancock; A. I. Andrews.

Walworth Company, New York, N. Y. Booth 525

Warren Electronics, Inc., Bound Brook, N. J. Booth 628

Warren Steam Pump Co., Inc., Warren, Mass. Booth 227
D.S. 193b—Showing of the Warren-Quimby hopper-type external gear & bearing screw pump. Equipped with plastic body pumping action of screws will be visible. To pump 200,000 SSU viscosity oil at press. to 300 lb./sq.in. & suction lifts to 20 in. Hg.
Bulletins: S-205 on the W-Q screw pump; S-206 illus. & des. double exter. bear. & gear type, & double exter. bearing & gear hopper type. WQ-50 on Streamflow Rotex pumps. Illus. & des. entire line of rotary pumps.

(Continued on page 118)

25TH DATA GUIDE TO THE CHEMICAL EXPOSITION

Personnel: W. B. Eklund, indus. sales mgr.; A. A. Zalis; R. G. Newell; J. A. Nibling.

Watertown Division, Watertown, N. Y. Booth 333-335
(See N. Y. Air Brake Co.)

Watson-Stillman Fittings Div., Roselle, N. J. Booth 722
D.S. 194—Forged carbon steel fittings; forged alloy & s.s. fittings; forged steel unions; orifice & spec. unions; 150 lb. s.s. fittings; air oper. & hand pumps.
Bulletins: S-3-55—on the 150 lb. s.s. fittings. Speci., sizes, ratings of new lightweight s.s. types 304 & 316 pipe fittings. S-1-55—forged s.s. & alloy steel pipe fittings—8-p. comp. infor. & engrg. data.
Personnel: J. Kemper, genl. mgr.; J. Tough, sales mgr.; A. Johnson; C. Liberg; J. Ocello.

Welch Manufacturing Co., Chi., Ill. Booth C-42

Welding Fittings Corp., New Castle, Pa. Booth 219

Welsbach Corp., Philadelphia, Pa. Booth 947

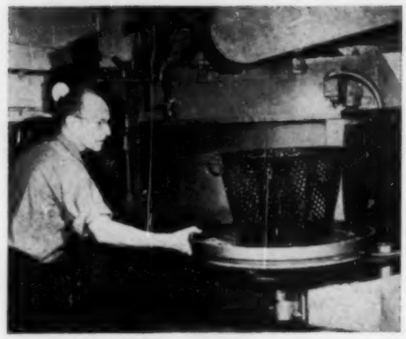
Wemco Div., San Francisco, Calif. Booth C-63
(See Western Machinery Co.)

Westinghouse Elec. Corp., Pitts., Pa. Booth 60
D.S. 195—New Cypak control a combination static, contactless control to perform same switching function as relays. Absence of moving parts increases life. Greatest use is where consid. amount of sequencing or interlocking is required such as chem. & petrol. proc. controls. Advantage is being inherently explos.-proof & no pts. sub. to corr. atmos.

Whitehead Metal Products Co., Inc., New York, N. Y. Booth 429

Whiting Corp., Harvey, Ill. Booth 932
(See Swanson Evaporator Co.)

Wheelabrator Corp., Mishawaka, Ind. Booth 133
D.S. 196—New Wheelabrator blast cleaning machine; a Liquamatte blast clean. mach., & a Wheelabrator Dustube dust & fume collector.
Bulletins: 106-D Wheelabrator Swing Table an airless blast clean. mach.; 451-D "40 Precision Finishing Operations" with the Liquamatte unit. 24-p. on the use of the Dustube. Cat. 72-B on dust & fume control. No. 555-D gives case



histories on use of Dustube collectors, in addition to others.
Personnel: L. L. Andrus, v. p. & exec. hd.; E. A. Rich, genl. sales mgr.; R. T. Pring, tech. dir.; R. L. Orth, fld. sales mgr.; G. H. Lieser; A. E. Lenhard.

Wiegand Co., E. L., Pittsburgh, Pa. Booth 810
D.S. 197—High press., high elec. rating flanged immersion heaters for process kettles; thermostat contained screw-plug type immer. htrs.; dir. htd. heaters for use with Dowtherm, Araclor, Prestone & other ht. tfr. media. The new item is an all-metal, far-infrared htg. element with Edison screw base to replace glass-bulb-type infrared htrs.
Bulletins: 32-p. booklet showing use of elec. ht. in plastic process.
Personnel: C. F. Kreiser, genl. sales mgr.; S. Campanella; W. L. Thompson; W. S. Eyth.

Wiggins Gasholder Div., Chi., Ill. Booth 42-44

Wiggins Vapor Seals Div. Chi., Ill. Booth 42-44
(See General Amer. Transportation Corp. on both)

Williams Patent Crusher & Pulveriser Co., St. Louis, Mo. Booth 709

Wolverine Tube Div., Detroit, Mich. Booth 642-644
(See Calumet & Hecla, Inc.)

Worthington Corp., Harrison, N. J. Booth 840, 848

Yarnall-Waring Co., Philadelphia, Pa. Booth 633

York Co., Inc., Otto H., W. Orange, N. J. Booth 516

York Corp., York, Pa. Booth 402

Young Radiator Co., Racine, Wis. Booth C-162

Combination hydrogen and carbon monoxide plant will be erected at National Aniline Division's Moundsville, W. Va. works, by the Girdler Company, Louisville, Ky. National Aniline, a division of Allied Chemical, will use the hydrogen and carbon monoxide as raw materials at the Moundsville works.

Process of the Girdler unit will be: Natural gas feed to a catalytic reformer furnace where hydrogen, carbon monoxide and carbon dioxide are produced by the steam-hydrocarbon reaction. Carbon dioxide removed by Girbotol process —a regenerative ethanolamine absorption system. Carbon-dioxide-free gas is dried, and carbon monoxide and hydrogen separated by low temperature fractionation. □

AEC plans to procure large additional quantities of high-purity zirconium and hafnium metal to meet the increasing requirements of its reactor development program, and of currently-scheduled Naval projects.

Tentative plans provide for 2 million pounds of zirconium to be delivered over a five-year period, or 1.2 million over a three-year period, with as much hafnium as can be produced from the zirconium to be processed.

AEC at the same time advises commercial producers to consider future non-Government markets which are sure to develop from private nuclear power projects. AEC does not intend to provide the zirconium and hafnium for these projects. □

News of the Field

FROM LOCAL SECTIONS

Louisville, Ky. The chemical engineer, in most cases, cannot be a lawyer, but when drawing up contracts it would help a lot if he were. Admitting that the engineer usually isn't a lawyer, the Louisville Section did the next best thing by inviting Tom Carroll of Greenbaum, Barnett and Carroll, attorneys, to address its September 19 meeting on the subject of the Contractual Liability of the Chemical Engineer.

Write your contract, and write it clearly and concisely. If not, you will be at the mercy of the interpretations of lawyers and judges. Make sure all plans and specifications are part of the contract, and be wary of fine print.

—F. G. Smith, Jr.

Baton Rouge, La. Reporting on Fourth World Petroleum Congress, A. Voorhies, Jr., Esso Laboratories, spoke to the September 22 meeting of the Baton Rouge Section.

—K. A. Rees

East Tennessee. There are two major reasons why a campaign for the development of a new product is undertaken. 1) A definite need exists for the product. 2) The company has the raw materials and the process at hand for making a new product.

Starting with these statements, J. E. Magoffin, Eastman Chemical Products, went deeply into the subject of New Product Development at the September 19 meeting of the East Tennessee Section.

Steps to the marketing of any new product usually follow this pattern: 1) Market survey. 2) Product approval sheet for management. 3) Patent study. 4) Preparation of technical literature. 5) Solution of packaging problems. 6) Actual production and stockpiling an adequate inventory prior to announcing product. 7) Development of prospect list. 8) Price determination and authorization. And many other concomitant operations such as toxicological studies and salesmen briefings.

—P. C. Underwood

Tulsa, Okla. A speech contest on technical subjects was the main attraction at the Tulsa Section's September 21 meeting. J. E. Gilliland and T. E. Griffith competed. Winner announced later.

The contest, brainchild of L. K. Cecil, is a unique plan of the Tulsa Section to foster public speaking ability in engineers, particularly the younger men in the section.

—J. H. Kelly

A.I.Ch.E. News of the Field

FROM LOCAL SECTIONS

Twin-Cities. In the second industrial revolution machines will, in part, replace men's minds with automatic equipment. This was the keynote of N. H. Ceaglske's talk on automation before the September meeting of the Twin-Cities Section.

Ceaglske, chemical engineer from the Univ. of Minnesota, charged that the chemical engineer is not yet contributing his proper share to the work in this field. Development of special instruments, analysis and design of control instruments, and the maintenance and overall studies of plant automation, all fall into the sphere of the chemical engineer.

—A. L. Frye

New Haven, Conn. Current officers for the new year of the New Haven Section are: E. L. Borg, Naugatuck, chmn.; J. J. Dorsey, Olin Mathieson, vice chmn.; R. W. Mickelson, Naugatuck, sec.; N. Phaneuf, Carwin Co., treas.

—E. L. Borg

Detroit, Mich. The first photomicrograph of the polio virus, and the metal shadowing technique developed to study the virus' composition and nature, were shown and described to the Detroit Section at its September 14 meeting by A. R. Taylor, Parke-Davis.

Taylor emphasized the meticulous attention to sterility maintained throughout the process of cultivation and inactivation of the three types of polio virus, and throughout the composition of the three into the vaccine.

—D. O. Remter

Charleston, S. C. 1955-56 officers of the Charleston (S.C.) Section are: C. J. Smith, Monsanto, chmn.; J. K. Harvey, Carbide, vice chmn.; A. W. Byer, Carbide, Secretary; C. H. Braithwaite, Jr., treas.; R. V. Green, Du Pont, member-at-large; A. K. Doolittle, Carbide, national vice president.

—A. W. Byer

Western Massachusetts. Drastic reduction of maintenance workers in the Air Force's Strategic Air Command despite the great increase in cost and complexity of aircraft, and without impaired efficiency, was the key fact of interest to Western Massachusetts Section engineers in a September 6 tour of Westover Air Force Base.

—R. T. Bogan

Pittsburgh, Pa. Officers of Pittsburgh Section for 1955-56: R. S. Rhodes, Koppers, chmn.; H. B. Coats, Blaw Knox, vice chmn.; J. R. West, Mellon Inst., sec.; F. W. Dittman, Rust Eng., treas.

—J. R. West

FUTURE MEETINGS and Symposia of the Institute

Note: The Author Information column will appear quarterly in the January, April, July and October issues.

MEETINGS — **SYMPOSIA**

■ LOS ANGELES, CALIF.
Feb. 26-29, 1956. Statler Hotel.
TECHNICAL PROGRAM CHAIRMAN: T. Weaver, Proc. Eng., The Fluor Corp., Ltd., Box 7030, East L. A. Station, Los Angeles 22, Calif.

New Techniques for Utilization of Fast Reactions & Freezing of Equilibria
CHAIRMAN: W. H. Corcoran, Cal. Inst. of Tech., 1201 E. Cal. St., Pasadena, Calif.

Current Status of the Completely Automatic Process Unit
CHAIRMAN: F. C. Brunner, C. F. Braun & Co., 1000 S. Fremont Ave., Alhambra, Calif.

Supervision of Technical Personnel (Panel)
CHAIRMAN: R. D. Gray, Cal. Inst. of Tech., 1201 E. Cal. St., Pasadena, Calif.

Air Pollution
CHAIRMAN: H. P. Munger, Syracuse Univ., Syracuse 10, N. Y.

ABC's of Machine Computation
CHAIRMAN: R. C. Johnson, Dept. of Chem. Eng., Wash. U., St. Louis 5, Mo.
Deadline Past

■ NEW ORLEANS, LA.
May 6-9, 1956
TECHNICAL PROGRAM CHAIRMAN: H. E. O'Connell, Assoc. Dir. Process Div., Sect., Ethyl Corp., Box 341, Baton Rouge, La.

Fundamental Mechanism in Boiling, Cavitation and Condensation
CHAIRMAN: R. R. Hughes, Shell Dev. Co., Emeryville, Calif.

Foreign Chemical Developments & their Effect on U. S. Chemical Industry
CHAIRMAN: C. W. Humphreys, Shell Chem. Corp. 50 W. 50th St., New York, N. Y.

Liquid Metals
CHAIRMAN: C. F. Bonilla, Dept. of Chem. Eng., Columbia U., N. Y. 17, N. Y.

Fluid Mechanics
CHAIRMAN: Harold Johnson, Dept. of Mech. Eng., U. of Calif., Berkeley.
Deadline—January 6, 1956

■ PITTSBURGH, PA.
Sept. 9-12, 1956
TECHNICAL PROGRAM CHAIRMAN: Carl C. Monrad, Carnegie Institute of Technology, Pittsburgh, Pa.

Mixing
CHAIRMAN: J. H. Rushton, Dept. of Chem. Eng., Purdue U., Lafayette, Ind.
Deadline—May 11, 1956

■ ANNUAL—BOSTON, MASS.
Dec. 9-12, 1956. Hotel Statler.
TECHNICAL PROGRAM CHAIRMAN: W. C. Rousseau, Proc. & Sales Eng., Badger Mfg. Co., 230 Bent St., Cambridge 41, Mass.
Deadline—August 9, 1956

MEETINGS — **SYMPOSIA**

■ WHITE SULPHUR SPRINGS, W. VA.
Mar. 13-19, 1957. The Greenbrier

■ SEATTLE, WASH.
June 9-12, 1957. Olympic Hotel

■ BALTIMORE, MD.
Sept. 15-18, 1957. Lord Baltimore

■ ANNUAL—CHICAGO ILL.
Dec. 8-11, 1957. Conrad Hilton

UNSCHEDULED SYMPOSIA

Extraction of Hydrocarbons for Chemical Use from Pipeline Gases
CHAIRMAN: E. E. Frye, J. F. Pritchard & Co., 210 W. 10th, Kansas City 5, Mo.

Distillation Computation Methods
CHAIRMAN: Wayne C. Edmister, California Res. Corp., Richmond, Calif.

Operations Research
CHAIRMAN: George D. Creelman, Creelman Assoc., 2245 Harcourt Dr., Cleve., O.

Filtration
CHAIRMAN: F. M. Tiller, Dept. of Eng., U. of Houston, Cullen Boulevard, Houston 4, Tex.

■ TERRE HAUTE, IND.
April 21, 1956. Rose Polytechnic Institute.
1-day meeting on Bio-Engineering sponsored by the Terre Haute Section, A.I.Ch.E.
CHAIRMEN: C. W. Smith and R. A. Shurter. Contact Mr. Shurter at Commercial Solvents Corp., Terre Haute, Ind.

For the first time, silicone rubber is being cured successfully using carbon black fillers instead of the conventional silica-type fillers.

This development in silicone rubber technology comes from the Silicones Dept. of Linde Air Products Co., a division of Union Carbide.

The development opens many new possibilites for silicone rubbers. □

A mercury cell chlorine-caustic plant will be built by the Solvay Process Division, Allied Chemical, near Brunswick, Ga.

Expected to be in production by December, 1956, the plant will have a capacity of 100 tons chlorine, 125 tons caustic, per day. □

New regional sales office of Perkin-Elmer Corp. will be located in Pasadena, Calif., will serve Western and Northwestern states. □

people

IN MANAGEMENT AND TECHNOLOGY

Richard W. Davis, pictured, appointed chief development engineer at the research lab of Metal & Thermit Corp., New Jersey. **Alvin S. Pollock** joins the company as process engineer and **Leonard L. Adler** takes over as senior development engineer at the East Chicago, Ind., plant.

Erwin J. Campbell recently appointed supervisor of process research, Research and Development Dept. at Acheson Colloids Co. The newly-defined position follows enlargement of the department's laboratory and pilot plant facilities.

George F. Jenkins to manager of chemical processing in the Nuclear Industrial Applications Dept. of the Union Carbide Nuclear Co.

Carbide and Carbon Chemicals Co. transfers **Robert E. Merrill** to Torrance, Calif. plant as area supervisor of polyethylene production.

Eger V. Murphree, president of Esso Research and Engineering Co., received an honorary degree of Doctor of Engineering from Brooklyn Polytechnic Institute. Mr. Murphree is the only petroleum figure so honored at the Institute's centennial celebration.

Esso announces also the appointment of **E. Lawrence Morton** to the staff of the research labs and **Gary M. Robb** to the Economics Div.

Glenn C. Putnam transferred to staff of technical section of Du Pont's Victoria, Tex. plant. He will serve as technical superintendent.

Arthur Phineas Weber will offer an introductory graduate course in nuclear engineering during the 1955-56 year at the Brooklyn Polytechnic Institute. The course is designed to acquaint engineers in all specialties with problems and techniques in the rapidly developing nuclear engineering field.

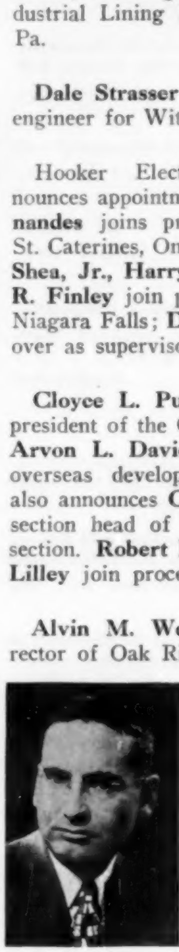
Kenneth Tator, head of Kenneth Tator Associates, Coraopolis, Pa., an engineering firm specializing in corrosion and abrasion protective methods, concludes in this issue his explanatory material and data on the Organic Coatings Indicator Chart (see page 88). Mr. Tator, who holds an M.S. in chemical engineering from M.I.T., has been associated with Dewey & Almy Chemical Company, Cambridge, Mass., the War Production Board, Washington, D. C., and the Industrial Lining Engineers, Pittsburgh, Pa.

Dale Strasser to materials handling engineer for Witco Chemical Co.

Hooker Electrochemical Co. announces appointments: **Dudley P. Fernandes** joins process study group at St. Caterines, Ont.; **R. T. Moore, J. F. Shea, Jr., Harry Dreifus** and **Aquila R. Finley** join process study group in Niagara Falls; **Dexter Edge, Jr.,** takes over as supervisor of the group.

Cloyce L. Purdom to asst. to the president of the Chemstrand Corp., and **Arvon L. Davies** to coordinator for overseas development. The company also announces **Carlyle J. Stehman** as section head of newly-created process section. **Robert H. Jones** and **Lon E. Lilley** join process group.

Alvin M. Weinberg appointed director of Oak Ridge National Laboratory by announcement of C. E. Center, vice-president of Union Carbide Nuclear Co., a division of Union Carbide and Carbon Corp. Weinberg had been research director of the laboratory and will now head this leading atomic research center.



S. A. Guerrieri appointed to technical staff of the Lummus Co.

Federated Metals Div. of American Smelting and Refining Co. names **George M. Baumann** to assist asst. to the president; **James F. McQuillan** named general manager of Midwestern Dept.; and **M. Robert Herman** is manager of Houston, Tex. plant.

George F. Sharrard to director of research and development of R. M. Hollingshead Corp.

Sharrard joined the company earlier this year as manager of the technical service division. He had been asst. to the director of sales development of Chas. Pfizer & Co., Inc.

Catalytic Construction Co. announces appointment of **George F. Klein, Jr.,** as chief engineer.

Klein will take charge of all engineering projects of the company under W. E. Kelley, vice-president of engineering. Prior to his present promotion, Klein had been manager of the Process Engineering Dept. He joined the company last year.

Gordon Clack advances to Midland Div. Technical Employment manager of Dow Chemical Co.

Carlton W. Crumb to new post of director of technical data and **Charles M. Comstock** to advertising manager at Dorr-Oliver, Inc.

Everett A. Bruce appointed asst. to the manager of manufacturing in the Industrial Chemicals Div. of Pennsylvania Salt Manufacturing Co. **Robert J. Cox** is superintendent of production at the Wyandotte, Mich. works of the Pennsalt.

Luigi Z. Pollara, formerly professor of mathematics at Stevens Institute of Technology, named head of the Dept. of Chemistry and Chemical Engineering at the school. He succeeds **Leslie H. Backer** who retired earlier this year.

John T. Connor elected president of Merck & Co., Inc., and **Henry W. Gadsden** to new position of executive vice president. Both men will sit on the Board of Directors of the company.

A. W. Crossley is executive vice-president of Shea Chemical Corp. He will headquarter in the home offices at Jeffersonville, Ind.

Roger Bart appointed manager of International Minerals & Chemical Corp.'s research experiment station. **W. B. Williams** is supervisor of chemical process development and **F. N. Oberg** is supervisor of coordinating services at the Florida experiment station.

CLASSIFIED SECTION

Address Replies to Box Number Care of CHEMICAL ENGINEERING PROGRESS

SITUATIONS OPEN

DIRECTIONS FOR USE OF CLASSIFIED SECTION

Advertisements in the Classified Section of Chemical Engineering Progress are payable in advance at 15c a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. Members may enter more than one insertion at half rates. Prospective employers and employees in using the Classified Section of Chemical Engineering Progress agree that all communications will be acknowledged; the service is made available on that condition. Boxed advertisements are available at $15 a column inch. Size of type may be specified by advertiser. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 15th of the month preceding publication.

CHEMICAL ENGINEERS AND CHEMISTS

Plant development and research on cellophane. Excellent opportunities for advancement. Salary open, depending on experience. Submit résumé and photograph. Box 9-11.

CHEMICAL ENGINEERS

Research minded. Capable of expressing self in concise reports. Two to five years' research and development experience in plastics processing. Education—Bachelor and/or Masters' in chemical engineering with good scholastic record.

Employment Supervisor
OLIN MATHIESON CHEMICAL CORP.
275 Winchester Avenue
New Haven 4, Connecticut

OPERATING SUPERVISOR—Small expanding company producing diversified industrial organic chemicals has opening for chemical engineering graduate with chemical plant operating experience. Unusual opening for man possessing individual initiative who is prepared to take charge of entire plant operations. Submit résumé and salary requirements. Box 8-11.

CHEMICAL ENGINEER OR PHYSICIST—Up to five years' experience. For research and process development in fiber spinning and related areas by application of chemical engineering unit processes, hydrodynamics and statistics. This is a permanent position in Celanese's expanding research laboratories in Summit, New Jersey. Please write complete details including salary desired to J. A. Berg. All inquiries in confidence. Celanese Corporation of America, Morris Court, Summit, N. J.

SITUATIONS WANTED

A.I.Ch.E. Members

CHEMICAL ENGINEER—M.S.Ch.E. experienced in petroleum plant technical service wishes to locate in New York, New Jersey or Connecticut. Presently employed by major oil company. Columbia graduate, 1948. Desires technical service or design work in petrochemicals. Box 3-11.

CHEMICAL EXECUTIVE—Broad industrial and executive experience heavy inorganics, electrochemistry, phosphates, rare and nuclear metals, potash, special organics—general manager, research director, consultation. Advanced degrees engineering, organic, inorganic; professional engineering registration. Box 4-11.

PRODUCTION ENGINEER—M.Ch.E. Age 37. Recognized thirteen year record of accomplishments in plant and process engineering, trouble-shooting, assistant to vice-president charge of production, chief engineer for multi-plant organization, plant manager of fermentation alcohol plant. Seeking responsible position in production, engineering or management. Box 5-11.

OLD MAN WANTS NEW JOB

Prefers technical management or supervision requiring broad experience, modern methods, and economic thinking. Chemical engineer with twenty-five years of engineering, research and production in technical and administrative positions. Doctorate, age 52. Location immaterial. Box 10-11.

CHEMICAL ENGINEER—Ph.D. Michigan, 1948. Age 33, married. Teaching, industrial research experience. Thermodynamics, heat and mass transfer, instrumentation. At present in Israel. Prefer position in process or plant design. Especially interested in petroleum or petrochemicals. Box 11-11.

CHEMICAL ENGINEER—Ph.D. with graduate business and legal training. Eight years' experience ranging from research and development to production and commercial development. Supervisory positions in petroleum, plastics, foods. Location immaterial. Box 12-11.

CHEMICAL ENGINEER—Twelve years' outstanding experience in development, production supervision, process design and construction covering wide product range. Age 34. B.S.Ch.E. "with high distinction." Sigma Xi, Tau Beta Pi. Offer knowledge, practical experience and understanding of human relations. Desire change to position of high potential requiring versatility beyond technical proficiency. Administration, liaison, staff consulting, sales. Prefer northeast. Salary $10,000 minimum. Box 13-11.

M.S.Ch.E.—Seeking change to operating responsibility from process control assignment. Married, 32. Eight years' experience in research, process development and control, pilot and production plant supervision. Present $9,600. Box 14-11.

CHEMICAL ENGINEER—Ph.D. Age 35. Supervisory experience in research and development. Present remuneration about $15,000. Desire a more responsible position. Box 15-11.

DIRECTOR OF RESEARCH—Registered professional chemical engineer. Statistics, data evaluation, linear programming, operations research, economic studies, pilot plant supervision. Publications. Present field, petroleum. Age 39, M.S.Ch.E. Box 16-11.

B.S.Ch.E.—1950. Age 29, family, veteran. Located in South. Five years' diversified development, design, and operational experience. All unit operations, electrochemical, solvent and liquid extraction, water and waste treatment, refrigeration, piping, instrumentation, and equipment layout. Box 17-11.

CHEMICAL ENGINEER—Age 30, family. Registered professional engineer. Seven years' industrial experience process development, design, and production in inorganics, fertilizers, and mineral processing including new plant start-ups, cost estimation and trouble shooting. Box 18-11.

PROCESS ENGINEER—B.S.Ch.E. 1951. Age 29, veteran, married. Four years' experience in process design of petrochemical plants for leading contracting company. Desire responsible position in East Coast offering a good future. Box 19-11.

CHEMICAL ENGINEER—B.S.Ch.E. 1941. Veteran, married. Age 36. Ten years' staff and supervisory experience in petroleum and petrochemicals with technical and process divisions of major oil company. Desire responsible position offering opportunity in production or engineering. Box 20-11.

CHEMICAL ENGINEER—B.S.Ch.E. 1951. Age 27, married, veteran. Four years' diversified experience in process design and development, organic chemicals. Also production experience. Desire process development work leading to responsible position in production management. Desire Midwest location. Box 21-11.

CHEMICAL ENGINEER—Age 39. Sixteen years' experience in production management, development, sales and administration including solid propellants, rockets, explosives, process equipment. Desire assignment as assistant to executive or manager. Mature, good personality, capable, industrious. Box 22-11.

the chemical engineer in MARKETING

Frank L. Rubin, widely known for his papers in the field of heat transfer design, joins sales engineering staff of Downingtown Iron Works, Inc. With 15 years' experience in the chemical petroleum and power industries, Rubin is also the author of technical papers on heat transfer and of instruction manuals in his field.

Richard N. Golbach, director of sales for the Central Scientific Co., elected a vice-president. Golbach joined the company in 1945 and assumed the position of director of sales last year.

Reichhold Chemicals, Inc., names **Herbert R. Helbig** general manager of the Export Div. Helbig will handle RCI's growing foreign sales and markets, making periodic visits to the company's foreign representatives to explore further expansion of business abroad.

John F. Taylor joins staff of Esso Research and Engineering Co. assigned to the Economics Division. Taylor had been with Shell Development Co. at the Emeryville, Calif. labs.

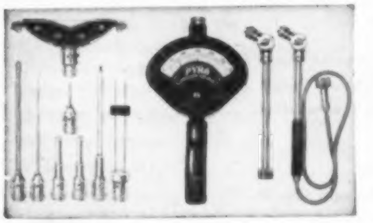
Joseph F. Coffey joins Development Div. of American Viscose Corp. as leader of newly-created commercial development section.

Norman E. Horton appointed overseas sales manager of Lion Oil Co. Div. of Monsanto Chemical Co. Horton has been export sales representative in New York. He will move to Arkansas to work from his new headquarters.

Robert P. Young named manager of New York district office of Peerless Pump Div. of Food Machinery and Chemical Corp.

Charles C. Snider appointed manager of field sales at Consolidated Engineering Corp. Snider will supervise several regional and district sales offices.

E. W. Baumgardner to sales manager of the Trabon Engineering Corp., Cleveland, to supervise national and international sales of the company's automatic lubrication systems.



the chemical engineer in

MARKETING

Alco Products, Inc., names **William L. Clark** product manager of the ALCOPLATE process. Clark will have charge of all phases of production, marketing and research involved in the company's new method of chemical nickel plating. He will headquarter at the Dunkirk, N. Y. plant.

John W. Pearson, pictured, to manager of New Products Div. of Minnesota Mining and Manufacturing Co. Pearson will assume responsibility for management and development of new businesses outside the present 3M industrial divisions. Joining the company in 1939, Pearson had been executive engineer since 1953.

Also announced is appointment of **Bertrand Y. Auger** as technical director of the Reinforced Plastics Division.

Frank G. Oswald appointed to newly-created position as manager of new product sales in the Synthetics Dept. of Hercules Powder Co. His duties include planning, coordinating and supervising introductory sales activities and sales promotion for the department.

John F. Ortner to asst. sales manager, molding compounds dept. of Durez Plastics Div., Hooker Electrochemical Co. Ortner headquarters at the Tonawanda, N. Y. offices of Durez.

Joseph L. deCillis to director of market research at Chas. Pfizer & Co., Inc.

Necrology

Norman C. Hill, 62, vice-president engineering and development, The C. P. Hall Co., Akron, O.

William N. Pritchard, Jr., 62, chief chemist, Chemical-Pigment-Metals Div., The Glidden Co., Collinsville, Ill.

Charles W. Simmons, 58, professor of chemical engineering, Lehigh U.

INDEX OF ADVERTISERS

C.E.P. Advertising Offices

New York 36—Lansing T. Dupree, Adv. Mgr.; John M. Goede, Asst. Adv. Mgr.; Paul A. Jolcuvar, Dist. Mgr.; Donald J. Stroop, Dist. Mgr.; 25 W. 45th St., Columbus 5-7330.

Chicago 11—Richard R. Quinn, Dist. Mgr., 612 North Michigan Ave., Room 507, Superior 7-0385.

Cleveland 15—Eugene B. Pritchard, Dist. Mgr., 1836 Euclid Ave., Superior 1-3315.

Pasadena 1—Richard P. McKey, Dist. Mgr., 465 East Union St., Ryan 1-8779.

news and notes

COUNCIL BUSINESS was heavy at the September meeting at the Lake Placid Club . . . two days were needed to consider it all . . . One main item was approval of a Council study on professional standards . . . Published in this issue, the report is essentially the work of a Council committee known first as the Doolitte Committee & then as the Dinsmore Committee (after the chairmen) . . . writing of the 3-page brochure took well over a year & has been discussed at every meeting of Council since the task was undertaken . . . We urge every member to read it & communicate ideas for implementation to the present chairman, Ray Dinsmore.

STATEMENT ON PROFESSIONAL STANDARDS now must be brought to the attention of employers & employees . . . Council fully realizes that mere publication is not a final answer & Council & all A.I.Ch.E. members are committed to the long haul of making sure that employees & employers alike understand the meaning of a true professional attitude.

CHAIRMEN FOR 1956: E. F. Jennings, Admissions; E. R. Gilliland, Awards; J. J. McKetta, Membership; F. E. Reese, Professional Development; L. J. Coulthurst, Program; W. E. Catterall, Research; Brymer Williams, Student Chapters . . . Decision on some committee chairmen was deferred & some are of course specified by constitutional or ex-officio provisions.

INSTITUTE SECTIONS COMMITTEE was reexamined & its functions divided in two . . . G. E. Holbrook is author of the new statement of purposes for the Local Sections Committee as accepted by Council . . . Essentially, the Institute Sections Committee, which will be headed for 1956 by Jack Dart, will take care of the formation of new sections . . . A new group will be formed under the chairmanship of some member of Council (he has yet to be appointed) for the purpose of assisting local sections, coordinating their activities, informing them through appropriate officers of the current plans & programs of the national organization, & acting as an active liaison with Council & the local groups . . . Purpose of this is to ensure Council's knowing what members are thinking, planning, & accomplishing at a local level . . . It is equally important for the local level to know what problems face Council . . . One of the important activities will be a meeting of local-section chairmen & vice-chairmen at National meetings . . . this all to be under the direction of the committee headed by a Council member & staffed by chairmen & vice-chairmen selected on a geographical basis from local sections.

NEW BY-LAW WAS PASSED by Council which asks that papers presented before local sections not be released to other publications before the national organization is informed of their existence . . . Wording & explanation of the by-law have alalready been sent to local section officers.

WELCOME, CENTRAL PENNSYLVANIA . . . Institute committee chairmen also reported to Council during the Lake Placid meeting, one report being from S. L. Lopata, chairman of the Institute Sections Committee, who presented the petition—which was accepted—from the Central Pennsylvania Chemical Engineers' Club to become a local section of the A.I.Ch.E.

NEW ENGINEERING CENTER reported on by President Dodge . . . Those who have followed the subject in these columns will remember our September report that the incumbent presidents of the five societies had recommended a six-point program . . . A.I.Ch.E. has now accepted this & appropriated $15,000 to carry on the task-committee work . . . A.I.Ch.E. representatives are B. F. Dodge, president; T. H. Chilton, past-president; & R. P. Kite, chairman of the Institute Housing Committee.

TASK COMMITTEE'S first meeting was held early in October; Dodge was elected chairman of the task group . . . Final report must be submitted by February 1 . . . Present problem is to select a firm to make an exhaustive study of a suitable location for the engineering center.

A. E. MARSHALL AWARD was designated by Council as the second prize in the Student Problem Contest . . . A. E. Marshall, former president of the A.I.Ch.E., bequeathed $3,000 to the Institute in trust, so that the income might be used for a student prize.

F.J.V.A.